BACHELOR THESIS & COLLOQUIUM – ME-141502

BIN PACKING PROBLEM FORMULATION FOR LNG DISTRIBUTION OPTIMIZATION FOR POWER PLANTS IN RIAU ISLANDS

JERICHO TUPAREV SIRINGORINGO
NRP 4213101024

Supervisor :
A. A. Bagus Dinariyana Dwi P., ST., MES., Ph.D
Co Supervisor :
Dr. Eng. Dhimas Widhi Handani, ST., M. Sc.

DOUBLE DEGREE PROGRAM OF
MARINE ENGINEERING DEPARTMENT
Faculty Of Marine Technology
Institut Teknologi Sepuluh Nopember-Hochschule Wismar
Surabaya
2017

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FORMULA *BIN PACKING PROBLEM* UNTUK OPTIMASI DISTRIBUSI LNG PADA PEMBANGKIT LISTRIK DI KEPULAUAN RIAU

JERICHO TUPAREV SIRINGORINGO
NRP 4213101024

Dosen Pembimbing I :
A. A. Bagus Dinariyana Dwi P., ST., MES., Ph.D
Dosen Pembimbing II :
Dr. Eng. Dhimas Widhi Handani, ST., M. Sc.

PROGRAM DOUBLE DEGREE
DEPARTEMEN TEKNIK SISTEM PERKAPALAN
Fakultas Teknologi Kelautan
Institut Teknologi Sepuluh Nopember-Hochschule Wismar
Surabaya
2017

APPROVAL FORM

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BACHELOR THESIS

Proposed to Fulfill One of The Requirements for Obtaining a Bachelor Engineering Degree
on
Reliability, Availability, Management and Safety (RAMS) Laboratory
Study Program Bachelor Double Degree of Marine Engineering Department
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember Surabaya

Prepared By:

JERICHO TUPAREV SIRINGORINGO

NRP. 4213 101 024

Approved by Supervisor and Co-Supervisor :

1. A. A. Bagus Dinariyana Dwi P., ST., MES., Ph.D (Dinariyana)
2. Dr. Eng. Dhimas Widhi Handani, ST., M. Sc. ( )

SURABAYA
July, 2017

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Prepared By:

JERICHO TUPAREV SIRINGORINGO

NRP. 4213 101 024

Approved by Head of Marine Engineering Department :

KEMENTERIAN RISET, TEKNOLOGI DAN PENDIDIKAN TINGGI
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
FAKULTAS TEKNOLOGI KELAUTAN
DEPARTEMEN TEKNIK SISTEM PERKAPALAN

Dr. Eng. M. Badrus Zaman, ST. MT.
NIP. 197708022008011007

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Prepared By:

JERICHO TUPAREV SIRINGORINGO
NRP. 4213 101 024

Approved by Representative Hochschule Wismar in Indonesia :

Dr.-Ing Wolfgang Busse

V

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Name : Jericho Tuparev Siringoringo
NRP : 4213 101 024

Bachelor Thesis Title	:	Bin Packing Problem Formulation for LNG Distribution Optimization for Power Plants in Riau Islands
Department	:	Double Degree Program in Marine Engineering

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NRP. 4213 101 024

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BIN PACKING PROBLEM FORMULATION FOR LNG DISTRIBUTION OPTIMIZATION FOR POWER PLANTS IN RIAU ISLANDS

Name	**: Jericho Tuparev Siringoringo**
NRP	**: 4213101024**
Department	**: Double Degree Program of Marine Engineering**
Supervisor	**: A. A. Bagus Dinariyana Dwi P., ST., MES., Ph.D**
Co-Supervisor	**: Dr. Eng. Dhimas Widhi Handani, ST., M. Sc.**

ABSTRACT

Indonesia's energy demand always increases on each year, from RUPTL that increased electricity needs in Indonesia are on an average of 8.6% each year and according to Government planning program for Indonesia Terang of 35,000 MW. In this program, the government wants to convert power plant that using diesel oil into LNG. Riau Islands are divided into Bintan Island, Karimun Island, and Dabo Singkep Island which has 77,5% power plant that using diesel oil. Based on RUPTL PLN 2015-2025 that PT. PLN (Persero) plans to build mini LNG plant in Riau Islands for the much small power plant which is spread around Riau Islands. From PT. Perta Arun Gas source, there is 12,5 MTPA capacity that can be an option to supply LNG for a power plant in Riau Islands. There are 16 diesel power plant will be supplied spread in Riau Islands. To distribute LNG for 16 power plants need optimization method to get the minimum investment. In this thesis, discusses the LNG as a fuel power plant in Riau Islands by specifying a suitable distribution pattern, Bin Packing Problem as a method, and the data facilities are should provided also the economic study. With the location LNG sourced from Arun Regas Facility and will be distributed to the Riau Islands with Barge Container Skid (BCS) which is possible to distribute the LNG from Arun Regas Facility. BCS supported with several capacities of LNG ship which are 12.000 m3, 7.500 m3, and 5.000 m3 as an option. On land, supported with two capacity of LNG trailers are 48,1 m3 and 61,7 m3. Optimization distribution later will determine the number of selected transport ships, as well as the route of distribution, type of ship and numbers of the trailer, will be used. The result of the thesis is expected to analyze the optimal route for the ship to distribute with certain possibilities type of ship and the economic study if the plant uses LNG as fuel. With optimization, obtain two BCS size 5.000 m3 with a certain route and requires six trailers size of 61.7 liters with certain routes. The total cost of this distribution of LNG are US $24,091,145 (CAPEX) and US $1,102,110

(OPEX). For the economic study which has been calculating the most optimal sales margins between the US $1.75 – US $2 with payback period 2.4-6.9 years of operating time for 20 years.

Key Words: Distribution of LNG, Bin Packing Problem Method, Vehicle Routing Problem, Economic Study

FORMULA *BIN PACKING PROBLEM* UNTUK OPTIMASI DISTRIBUSI LNG PADA PEMBANGKIT LISTRIK DI KEPULAUAN RIAU

Nama	**: Jericho Tuparev Siringoringo**
NRP	**: 4213101024**
Jurusan	**: Teknik Sistem Perkapalan Double Degree**
Pembimbing I	**: A. A. Bagus Dinariyana Dwi P., ST., MES., Ph.D**
Pembimbing II	**: Dr. Eng. Dhimas Widhi Handani, ST., M. Sc.**

ABSTRAK

Permintaan energi Indonesia setiap tahun selalu meningkat, sumber RUPTL menyatakan peningkatan kebutuhan listrik di Indonesia rata-rata 8.6% setiap tahun dan merujuk kepada program pemerintah untuk Indonesia Terang yaitu 35.000 MW. Pada program ini, pemerintah ingin mengubah konsumsi bahan bakar pembangkit dari solar ke LNG. Kepulauan Riau terdiri dari Pulau Bintan, Pulau Karimun, Pulau Dabo Singkep dimana 77.5% pembangkit listrik menggunakan solar. Merujuk kepada RUPTL PLN 2015-2025 bahwa PT. PLN (Persero) merencanakan mendistribusikan LNG untuk pembangkit listrik di Kepulauan Riau yang tersebar. Berdasarkan PT. Perta Arun sumber gas, terdapat kapasitas 12,5 MTPA yang dapat menjadi pilihan untuk supplai LNG pada pembangkit listrik di Kepulauan Riau. Terdapat 16 pembangkit listrik diesel yang akan di supplai tersebar di Kepulauan Riau. Untuk mendistribusikan LNG kepada 16 pembangkit listrik, membutuhkan optimasi untuk mendapatkan investasi yang minimum. Pada tesis ini, membahas tentang LNG sebagai bahan bakar di Kepulauan Riau dengan menetapkan jalur distribusi yang cocok. Metode *Bin Packing Problem* dan data fasilitas harus terpenuhi dan juga kajian ekonomi nya. Dengan mengambil sumber dari kilang Arun dan mendistribusikan ke Kepulauan Riau menggunakan *Barge Container Skid* (BCS) dimana paling memungkinkan untuk mendistribusikan LNG dari kilang Arun. *BCS* terdapat berbagai jenis kapasitas yaitu 12.000 m^3, 7.500 m^3, dan 5.000 m^3 sebagai pilihan. Pada jalur darat, direncanakan menggunakan dua jenis kapasitas dari trailer LNG yaitu 48,1 m^3 dan 61,7 m^3. Optimasi distribusi kemudian menentukan jumlah kapal, jenis kapal, jalur kapal, dan jumlah trailer yang akan digunakan. Hasil dari tesis ini diharapkan dapat menganalisa rute optimal untuk kapal mendistribusikan, ukuran kapal dan kajian ekonomi jika pembangkit listrik menggunakan bahan bakar LNG. Dengan optimasi, diperoleh dua kapal *BCS* ukuran 5.000 m^3 dengan rute tertentu dan enam *trailer* ukuran 61,7 liter dengan rute tertentu juga. Total biaya dari distribusi LNG ini adalah US

$24,091,145 (*CAPEX*) dan US $1,102,110 (*OPEX*). Untuk kajian ekonomi yang telah dihitung untuk *margin* penjualan diantara US $1.75 – US $2 dengan *payback period* 2.4-6.9 tahun selama operasi 20 tahun.

Kata Kunci: Distribusi LNG, Metode *Bin Packing Problem*, *Vehicle Routing Problem*, Kajian Ekonomi

PREFACE

Thanks to God for his grace and favor, so the writer with the Bachelor thesis title of "Bin Packing Problem Formulation for LNG Distribution Optimization for Power Plants in Riau Islands" has been done. The Bachelor thesis made for the requirement to graduate from Marine Engineering Department, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember-Hochschule Wismar, Surabaya-German. During the bachelor thesis, the writer got help, support and want to thank:

1. Jesus Christ for his grace and favor so the writer can finish the bachelor thesis completely.
2. My super family for supporting during this bachelor thesis. And of course to my lovely dad Ir. Ezion Zeber Siringoringo S.E., MM and my lovely mom Ir. Miliana Panjaitan. Praise to God.
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Surabaya, July 2017

Jericho Tuparev Siringoringo

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CHAPTER I
INTRODUCTION

1.1 Background

The Riau Islands province has a very convenient geographical position because it is at the entrance to the Malacca Strait from the East and it also conterminal by the business and financial in the region of Southeast Asia. Province of Riau Islands it is possible to become one of the centers of economic growth for the Republic of Indonesia in the future. Moreover, currently at some areas in Riau Islands (Batam, Bintan, and Karimun), Middle attempted as a pilot project the development of Kawasan Ekonomi Khusus (KEK) through collaboration with the Government of Singapore. The Riau Islands province includes the city of Tanjung Pinang, Bintan, Batam, Karimun Regency, Natuna Regency, and Anambasyang Regency consist of large and small 2,408 Islands where 40% has not yet been named and populated, with 95% of its territory is the ocean. (1)

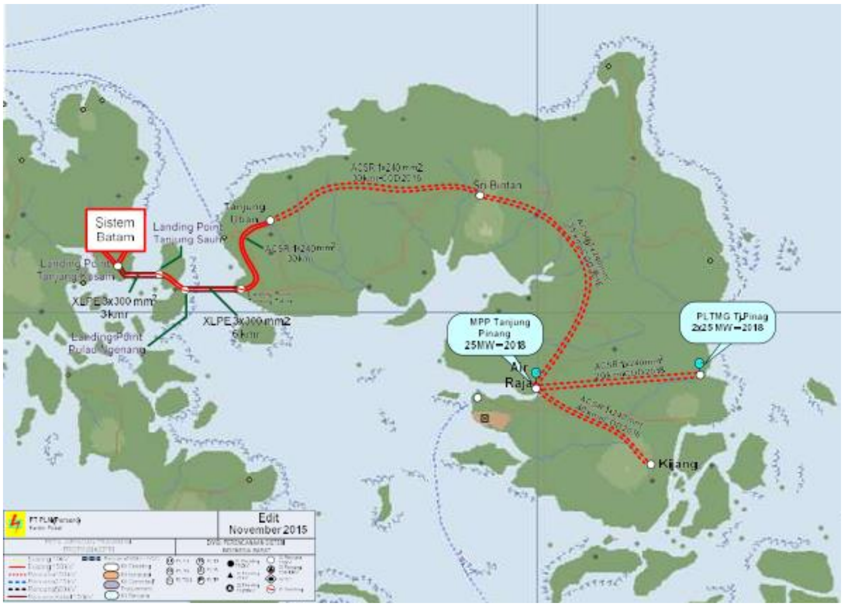


Figure 1. 1 Map of the province of Riau Islands
(source: RUPTL PLN 2016-2025)

The application of the policy of KEK in the Batam-Bintan-Karimun is a form of cooperation between the Central Government and closely local governments with the participation of the business world. KEK's future is a set of the Center's flagship economic activities that need to be supported by the infrastructure with international standard.

Riau Islands need support electric power supply is sufficient and reliable especially in the Tanjung Pinang which is the capital city of the province of Riau Islands. The power supply for the city of Tanjung Pinang system supplied through Tanjung Pinang which serves 3 administrative areas, namely the Riau Islands province, the municipality and Regency Tanjung Pinang and Bintan. Tanjung Pinang System supplied from a PLTD Air Raja and PLTD Suka Berenang and Tokojo MG/PLTG, PLTG/MG Dompak and PLTU Galang Batang with the capacity 122,15MW power capable of 55.5 MW while peak load current has been reached through a network of 20 MW 57.3 kV.

The administrative area is also growing rapidly, namely, the Karimun Regency is in the supplied System from Tanjung Balai Karimun. The system in the supply of PLTD Bukit Carok and PLTU TBK FTP 1 (1 x 7 MW) with installed capacity total 37.17 MW with power capable 22.8 MW while peak load current has reached 24.2 MW. Isolated systems spread out more in the Riau Islands province has installed capacity of 77.11 MW with power capable 50.14 MW while peak load current has reached 36.95 MW. (1)

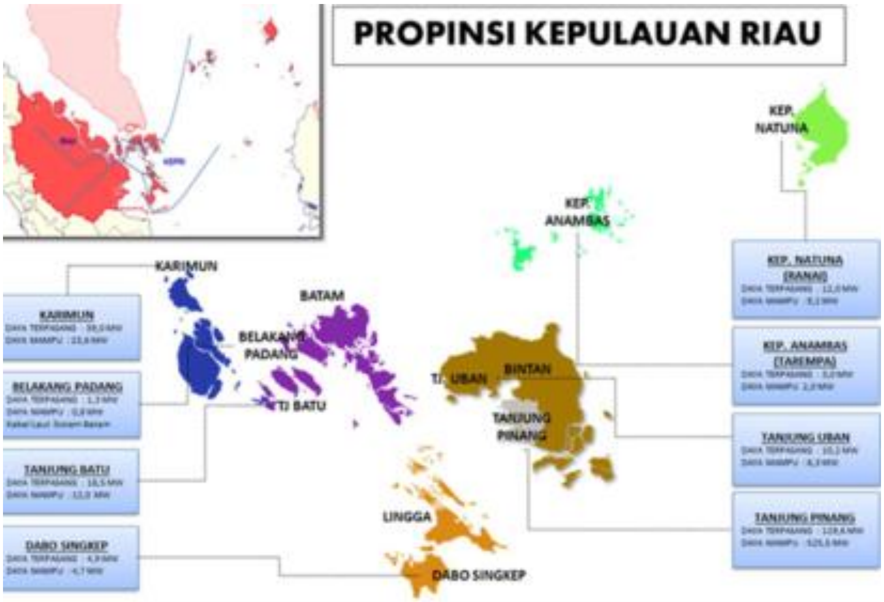


Figure 1. 2 Map of system in the province of Riau Islands
(source: RUPTL PLN 2016-2025)

Isolated systems in the province of Riau Islands have 249 small generators units with a total capacity of 469 MW and a power able to 337.4 MW in the Table 1.1.

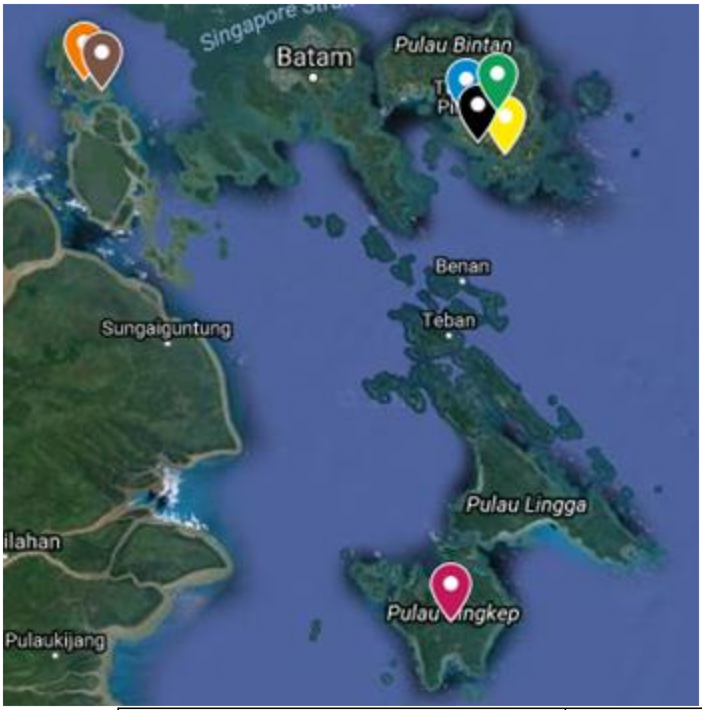
Table 1. 1 *Existing plants*

No	Power Plants	Type	Type of fuel	Owner	Capacity on set (MW)
1	Spread WRKR	PLTD	HSD	PLN	87.5
2	KOTA LAMA	PLTD	HSD	PLN	23.9
3	AIR RAJA	PLTD	HSD	PLN	56.2
4	SUKA BERENANG	PLTD	HSD	PLN	42.3
5	BUKIT CAROK	PLTU	Coal	PLN	14.0
6	BUKIT CAROK	PLTD	HSD	PLN	22.2
7	AIR RAJA (SW)	PLTU	Coal	PLN	30.0
8	BUKIT CAROK (SW)	PLTD	HSD	Rent	22.2
9	AIR RAJA (SW)	PLTGB	HSD	Rent	30.0
10	TANJUNG BATU (SW)	PLTBM	Biomass	Rent	4.8
11	SUKABERENANG (SW)	PLTD	HSD	Rent	42.3
12	AIR RAJA (SW)	PLTD	HSD	Rent	56.2
13	KOTA LAMA (SW)	PLTD	HSD	Rent	23.9
Total					**455.45**

(source: RUPTL PLN 2016-2025)

Table 1. 1 *Total of capacity need to supply*
(source: RUPTL PLN 2016-2025)

Power Plant Name		Capacity (MW)	LNG need (mmscfd)
Karimun Island			
1.	PLTU Tanjung Balai Karimun-1	40 MW	8 mmscfd
2.	PLTU Tanjung Balai Karimun-2	7 MW	1,4 mmscfd
3.	PLTG/MG Tanjung Balai KarimunPeaker	20 MW	4 mmscfd
4.	PLTD Bukit Carok	22,2 MW	4,44 mmscfd
5.	PLTD Bukit Carok (SW)	22,2 MW	4,44 mmscfd
TOTAL = 111,4 MW			**22,28 mmscfd**
Dabo Singkep Island			
1.	PLTMG DaboSingkep	20 MW	4 mmscfd
2.	PLTMG Dabo Singkep-1	10 MW	2 mmscfd
TOTAL = 30 MW			**6 mmscfd**
Bintan Island			
1.	PLTD Air Raja	56,2 MW	11,24 mmscfd
2.	PLTD Air Raja (SW)	30 MW	6 mmscfd
3.	PLTD Air Raja (SW)	56,2 MW	11,24 mmscfd
4.	PLTMG Tanjung Pinang-1	25 MW	5 mmscfd
5.	PLTMG Tanjung Pinang	50 MW	10 mmscfd
6.	PLTD Kota Lama	23,9 MW	4,78 mmscfd
7.	PLTD Kota Lama (SW)	23,9 MW	4,78 mmscfd
8.	PLTD Sukaberenang	42,3 MW	8,46 mmscfd
9.	PLTD Sukaberenang (SW)	42,3 MW	8,46 mmscfd
TOTAL = 349,8 MW			**69,96 mmscfd**
TOTAL = 491,2 MW			**98,24 mmscfd**



PLTD AIR RAJA	142,4 MW
PLTD BUKIT CAROK	44,4 MW
PLTD SUKA BERENANG	84,6
PLTMG TANJUNG PINANG	75 MW
PLTU TANJUNG BALAI KARIMUN	67 MW
PLTMG DABO SINGKEP	30 MW
PLTD KOTA LAMA	47,8 MW

Figure 1. 3 *List of power plants in Riau Islands*

Based on the table above, it can be stated that the majority of plants found in the Riau Islands are still using oil fuel (Diesel) as a fuel for power plants with a total installed power of 455.45 MW. Based on the condition of the electrical system in the Riau Islands, consumption of diesel fuel use as fuel amounted become 491,2 MW which means 98,24 mmscfd is 1.571.840 m3 should be in supply. Then it would impact on oil imports by PT. Pertamina as the company who is responsible for fuel throughout Indonesia. (1)

Year	Economic Growth (%)	Sales (Gwh)	Production (Gwh)	Peak Load (MW)	Costumer
2015	6.8	745	817	152	220.791
2016	7.2	812	888	165	235.882
2017	7.4	886	965	179	251.763
2018	7.5	968	1.051	195	268.530
2019	7.3	1/059	1.159	213	286.271
2020	7.3	1.160	1.258	233	305.141
2021	7.3	1.273	1.381	255	325.307
2022	7.3	1.401	1.518	280	346.940
2023	7.3	1.545	1.673	308	363
2024	7.3	1.707	1.847	340	383.303
Growth	7.3%	9.6%	9.5%	9.4%	6.3%

Figure 1. 4 *Electric power needs*
(source: RUPTL PLN 2016-2025)

Economic growth of Riau Islands is estimated will continue to increase in the coming years, where high economic growth target to the attention of investors to increase the capital in the province of Riau Islands.

Gas reserves in Indonesia which are 141 Tcf, surely will be able to reduce oil demand and reduced supply demand GAP of Indonesian oil. With the largest gas reserves in Indonesia, which is the nearest is Arun relatively close with Riau Islands, it will be more efficient and economical if power plant in Riau Islands using LNG. (2)

1.2 Statement of Problems

According to the background of Bachelor thesis, the several points of problem are:

1. How to determine the most optimal of LNG supply & distribution in Riau Islands?
2. How to determine facilities which are supporting for LNG distribution in Riau Islands?
3. How is the economic study of the distribution of LNG design for power plants in Riau Islands?

1.3 Research Limitation

Research limitation of the problem of this bachelor thesis is:

1. Arun is ready and able for supplying in Riau Islands
2. LNG Supplier is only from Arun
3. The price of LNG is assumed to equal with the price of LNG in Arun

4. Supply and distribution LNG is for Diesel power plant, Gas Power Plant, and Steam Gas Power Plant in Riau Islands
5. Supply LNG only for the certain power plant which already aimed
6. In this bachelor thesis, the writer not design about the receiving facilities for each power plants.
7. The transportation selection for the ship is only from Barge Container Skid (BCS) with 12.000 m^3, 7.500 m^3, and 5.000 m^3. For the trailer only from Chart Inc. with ST-12700 (48,1 m^3) and ST-16300 (61,7 m^3).
8. For the investment cost only for entire transportation and facilities receiving terminal LNG that will be found.

1.4 Research Objectives

The several aims for this bachelor thesis are:

1. To determine the best LNG distribution and optimization for power plants in Riau Islands
2. To determine the facilities that will be supporting during LNG distribution expected the very efficient supply chain with have minimum investment cost for power plants in Riau Island
3. To determine the economic study of LNG distribution will be build in Riau Island area.

1.5 Research Benefits

There are some benefits that can be obtained in this bachelor thesis:

1. To give the method by Bin Packing Problem for the most optimal LNG distribution in Riau Islands, Indonesia.
2. To determine the facilities LNG distribution for the implementation in Riau Islands, Indonesia.
3. To give the investment cost (NPV, Payback Period, and IRR) of LNG distribution in Riau Islands, Indonesia.

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CHAPTER II
LITERATURE STUDY

2.1 Description of LNG

Liquefied natural gas (LNG) is natural gas (predominantly methane, CH_4, with some mixture of ethane C_2H_{6f}) that has been converted to liquid form for ease of storage or transport. It takes up about 1/600th the volume of natural gas in the gaseous state. It is odorless, colorless, non-toxic and non-corrosive. Hazards include flammability after vaporization into a gaseous state, freezing and asphyxia. The liquefaction process involves removal of certain components, such as dust, acid gases, helium, water, and heavy hydrocarbons, which could cause difficulty downstream. The natural gas is then condensed into a liquid at close to atmospheric pressure by cooling it to approximately −162 °C (−260 °F); maximum transport pressure is set at around 25 kPa (4 psi). (3)

Boiling temperature at atmospheric pressure	-162 °C -260 °F
Volume reduction compared to gaseous state	1:600
Typical density	450 kg / m³ 28lb / ft 1 tonne LNG = 2.2 m³
Maximum transport pressure	25 kPa 4 psi
Typical Higher Heating Value	50 MJ / kg 21,500 Btu / lb
Typical Lower Heating Value	45 MJ / kg 19,350 Btu / lb
Typical Energy Density Value (based on higher heating value) (based on lower heating value)	 22.5 MJ / liter 20.3 MJ / liter
Relative Energy Density of LNG compared to: Diesel Gasoline LPG propane Compressed Natural Gas (CNG)	 60% 65% 90% 250%

Figure 2. 1 *LNG Facts*
(source: 2016 LNG Solutions Wartsila)

2.2 Natural Gas Source in Indonesia

According to Ministry of E&MR, Indonesia had 170,07 trillion cubic feet (Tcf) of proved natural gas reserves as of January 2014, making it the 14th largest holder of proved natural gas reserves in the world, and the third largest in the Asia-Pacific region. The country continues to be a major exporter of pipeline and liquefied natural gas (LNG). At the same time, domestic consumption of natural gas has nearly doubled since 2004. Natural gas shortages caused by production problems and rising consumption forced Indonesia to buy spot cargoes of LNG to meet export obligations. The government committed to constructing new LNG receiving terminals and gas transmission pipelines to address domestic gas needs, though this could reduce the natural gas available for export.

Indonesia's gas production is the highest in Asia. The main producing areas are in northern Sumatra, Java, and eastern Kalimantan. Natural gas production has increased by over a third since 2005. While Indonesia still exports about half of its natural gas, domestic consumption is increasing. Indonesia has for many years been the world's leading exporter of LNG. The principal domestic consumers of natural gas (apart from the oil and gas industry) are power stations, fertilizer plants, and industrial users; the residential, commercial and transportation sectors have relatively small shares. (2)

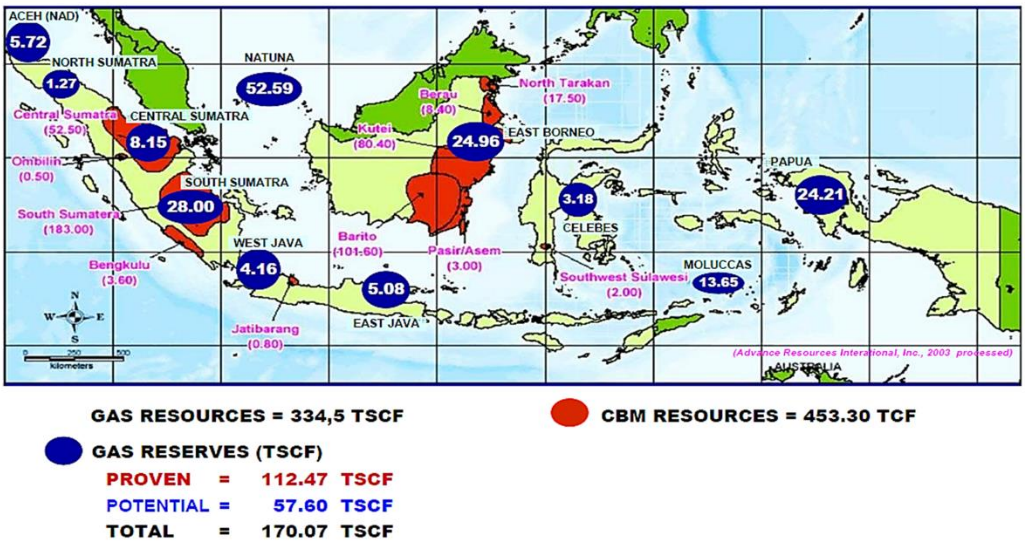


Figure 2. 2 *LNG Source in Indonesia*
(source: Ministry of E&MR Indonesia 2015)

2.3 Arun Refinery

PT. Perta Arun Gas as Indonesia's first inland LNG Receiving and Regasification Terminal located in Blang Lancang, Lhokseumawe, Aceh. 6 LNG Plant, total capacity 12.5 MTPA with 5 LNG Storage Tank, total capacity 636,000 m3 and 2 LNG Jetty each 80,000 DWT. According to PT. Perta Arun Gas, the LNG total capacity about 12,5 MTPA which mean 27.500.000 m3 is ready to provide LNG need in Indonesia. From RUPTL PLN 2016-2025, the power plant in Riau Islands needs about 491,2 MW which means 98,24 mmscfd become 1.571.840 m3. From the information above it, will possible to provide power plants need in Riau Islands. (4)

Figure 2. 3 Arun Refinery
(source: PT. Perta Arun Gas, Pertamina)

2.4 LNG Supply Chain

- Exploration – production

At the heart of this essential activity, specialists analyzye geological structure to identify areas that may contain hydrocarbons. They carry out special tests, such as seismic analysis, to confirm their initial assessments. Drilling is undertaken when there is a high probability of discovering gas (or oil).

- Liquefaction

The natural gas extracted from the deposit is filtered and purified, so as not to damage equipment during the conversion from gas to liquid, and in order to meet the specifications of the importing regions. This means that the liquefaction process produces a natural gas with a methane content close to 100%. Liquefaction plants often consist of several installations arranged in parallel, called "liquefaction trains". The liquefaction process reduces the volume of gas by a factor of around 600, in other words 1 cubic meter of LNG at -163°C has the same energy content as 600 cubic meters of "gaseous" gas at ambient temperature and atmospheric pressure. The density of LNG is around 45% that of water.

- LNG transportation

LNG tankers are double-hulled ships specially designed to prevent hull leaks and ruptures in the event of accident. The LNG is stored in tanks (generally 4 to 5 per tanker) at a temperature of -163°C and at atmospheric pressure. There are currently 3 types of LNG carrier, depends on tank design:

1. Membrane tanks,
2. Spherical tanks and
3. IHI Prismatic tanks.

- Storage and regasification

Once received and offloaded, the liquefied natural gas is returned to cryogenic storage tanks – usually varying in capacity from 100,000 to 160,000 cubic meters, depending on the site – where it is kept at a temperature of -163°C prior to regasification. Regasification consists of gradually warming the gas back up to a temperature of over 0°C. It is done under high pressures of 60 to 100 bar. (4)

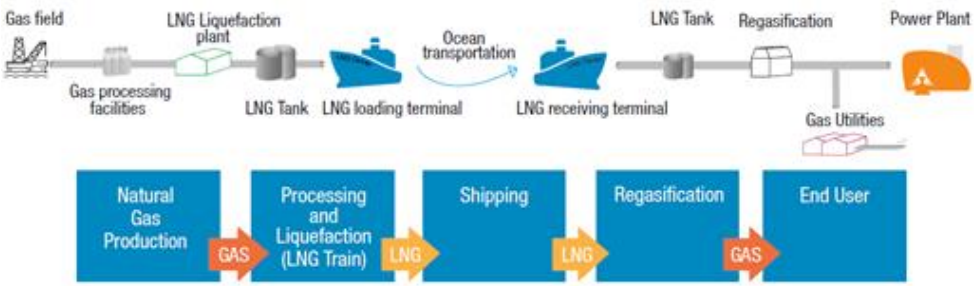


Figure 2. 4 *LNG Supply Chain*
(source: http://www.natgas.info/)

2.5 LNG Supplier

- LNG Plant

Liquefaction and purification facility. In order to make it practical and commercially viable to transport natural gas from one country to another, its volume has to be greatly reduced.

- LNG Vessel

The majority of new ships under construction are in the size of 120,000–140,000 m^3 (4,200,000–4,900,000 cu ft), but there are orders for ships with capacity up to 260,000 m3 (9,200,000 cu ft). As of 2011, there were 359 LNG ships engaged in the deep sea movement of LNG. In the case of small scale LNG carriers (LNG carriers below 40,000 cbms), the optimal size of a ship is determined by the project for which it is built, taking into consideration volume, destination and vessel characteristics.

- LNG Receiving Terminal

Liquefied natural gas terminals can be divided into two types:

1. Liquefaction terminals and
2. Regasification terminals or receiving terminals.

FSRU, a floating storage and regasification unit, or FSRU for short, is an LNG terminal whose main structure is a special ship that is moored next to the port.

- LNG Storage Tank

LNG storage tanks can be found in ground, above ground or in LNG carriers. The common characteristic of LNG Storage tanks is the ability to store LNG at the very low temperature of -162 °C (-260 °F). LNG storage tanks have double containers, where the inner contains LNG and the outer container contains insulation materials. The most common tank type is the full containment tank. Tanks vary greatly in size, depending on usage.

- LNG Regasification

Regasification is a process of converting liquefied natural gas (LNG) at −162 °C (−260 °F) temperature back to natural gas at atmospheric temperature.

2.6 Bin Packing Problem Method

Bin packing is the problem of trying to find a set of objects to pack into containers (or bins). The objects have weights (or volumes), and each container has a *capacity*, which is the total weight (or volume) the container can hold. There are many variants of the problem: the objects can have different values whose sum should be maximized, sizes along different dimensions whose sums must adhere to certain limits, and there might be many containers or just one. (5)

Bin Packing Problem (BPP) using terminology of knapsack problem. As example given n items and n knapsacks (or bins), with

wj = *weight* of item j,

c = *capacity* of each bin,

All these should be arrange each item to each bin no exceed c and the number of bins used is a minimum as a limitation. Where the formula of the problem in mathematical is,

$$\text{minimize} \quad z = \sum_{i=1}^{n} y_i$$

$$\text{subject to} \quad \sum_{j=1}^{n} w_j x_{ij} \le c y_i, \quad i \in N = \{1, \ldots, n\},$$

$$\sum_{i=1}^{n} x_{ij} = 1, \quad j \in N,$$

$$y_i = 0 \text{ or } 1, \quad i \in N,$$

$$x_{ij} = 0 \text{ or } 1, \quad i \in N, j \in N,$$

where,

$$y_i = \begin{cases} 1 & \text{if bin } i \text{ is used;} \\ 0 & \text{otherwise,} \end{cases}$$

$$x_{ij} = \begin{cases} 1 & \text{if item } j \text{ is assigned to bin } i; \\ 0 & \text{otherwise.} \end{cases}$$

Assumed, wj are positive integers, c is a positive integer, wj ≤ c for j ϵ N. In the bin packing problem, objects of different volumes must be packed into a finite number of bins or containers each of volume V in a way that minimizes the number of bins used. In computational complexity theory, it is a combinatorial NP-hard problem. The decision problem (deciding if objects will fit into a specified number of bins) is NP-complete.

Bin Packing Problem work determining the smallest number of rolls of a fixed width that have to be cut in order to satisfy the demand of clients such as:

- Filling up containers;
- Loading trucks with weight capacity constraints;
- Creating file backups;
- Placing data on multiple disks;
- Job scheduling.

Given a positive integer number of bins m of capacity W and a list of n items of integer sizes w 1 ,...,w n (0 ≤ w i ≤ W), the problem is to assign the items to the bins so that the capacity of the bins is not exceeded and the number of bins used is minimized.

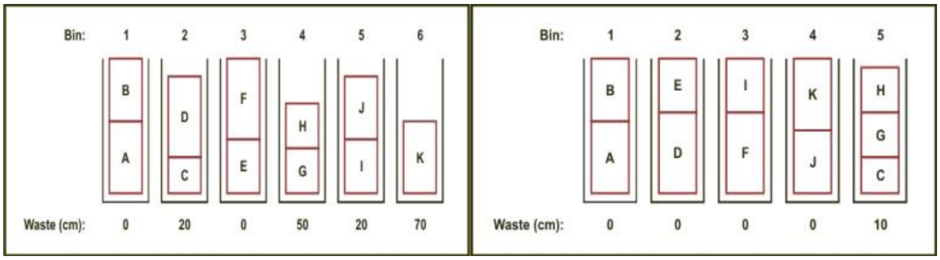


Figure 2.5 Bin Packing Example

So, if we take an example as one of the most common bin packing problems is Knapsacks.

A knapsack is a bin-packing problem, in which the goal is to maximize the total value of items in (typically) a single bin. In this documentation you'll learn how to use or-tools to solve knapsack problems.

Figure 2.5 Bin Packing Illustration

In the above figure, 50 items are packed into a bin. Each item has a value (the number on the item) and a weight (roughly proportional to the area of the item). The bin is declared to have a capacity of 850, and our goal is to find the set of items that will maximize the total value without exceeding the capacity. (6)

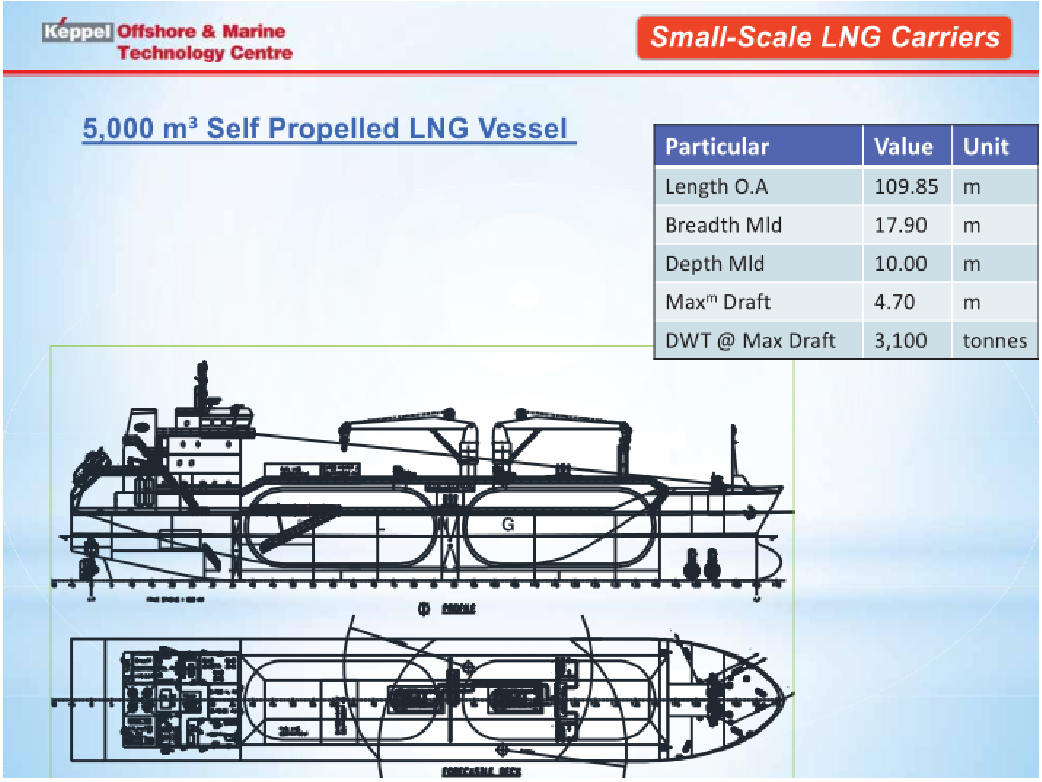
2.7 Barge Container Skid

Regular sized LNG vessels can't enter to those locations. Hence small-scale LNG carriers are necessary for transporting LNG to those remote locations. There are challenges in Small Scale LNG Transportation which is a necessity based transportation method. Customized designs are required for each case to transport LNG, initial investment is a factor in developing Small-Scale LNG infrastructures, requires a sustainable transportation model to compete with road transportation in future, once the infrastructures are fully developed, need to consider the problems in coastal and river waterway transportation, which will affect the (5):

- Designs of small coastal LNG carriers/ river barges
- Design of small LNG terminal, loading/unloading facilities

Barge Container Skid also divided into:

- Based on the propulsion system-
  1. Self Propelled LNG Carrier
  2. Non-Propelled LNG Carrier, powered by Articulated Pusher Tug
- Based on LNG Containment system-
  1. 'Type-C' LNG Tanks
  2. 'Membrane Type' LNG Tank
- Based on the Draft Limitation of the waterways-
  1. Regular draft LNG Carriers
  2. Shallow Draft LNG Carriers



Particular	Value	Unit
Length O.A	109.85	m
Breadth Mld	17.90	m
Depth Mld	10.00	m
Max^{m} Draft	4.70	m
DWT @ Max Draft	3,100	tonnes

Figure 2. 5 *LNG Carrier Barge*
(source: Small-scale LNG Carriers, Keppel Offshore & Marine Technology Centre)

2.8 Optimization Method

Optimization method is a method of design and operation of a system or process to create designs that optimal might be in terms of maximizing or minimizing. In the optimization system designed adjust various parameters to be used in an effort to get better results or economical side.

2.9 Vehicle Routing Problem (VRP)

The vehicle routing problem (VRP) is a combinatorial optimization and integer programming problem seeking to service a number of customers with a fleet of vehicles. Proposed by Dantzig and Ramser in 1959, VRP is an important problem in the fields of transportation, distribution, and logistics. The objective of the VRP is to deliver a set of customers with known demands on minimum-cost vehicle routes originating and terminating at a depot. In the two figures below we can see a picture of a typical input for a VRP problem and one of its possible outputs (7):

Purpose Function:
Min = $\sum_i \sum_j (Distance_{ij} \quad x \quad X_{ij})$

Constraint 1 (leave place)
$\sum_i \sum_j X_{ij}$=1 $\quad \forall_i$ i≠j

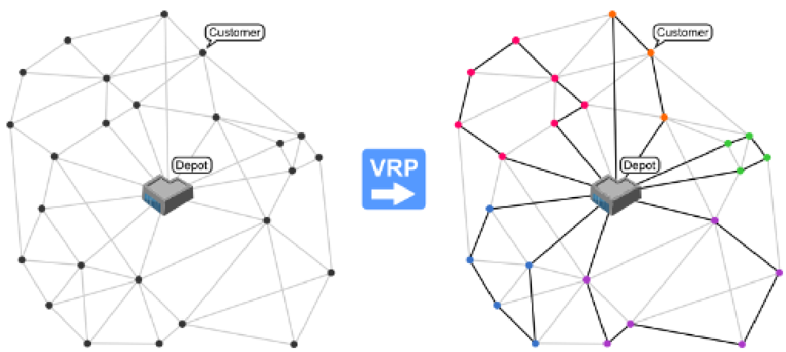
Constraint 2 (enter place)
$\sum_i \sum_j X_{ij}$=1 $\quad \forall_j$ j≠i

Constraint 3 (transportation cant back to the previous place)
Node*X_{ij}+ U_i - U_j ≤ (Node-1)

Constraint 4
Biner

Information:

U	= sequence of places
Distance	= distances between places
X	= variable of decision (biner)
Node	= total of node



An instance of a VRP (left) and its solution (right)

Figure 2. 6 VRP solution example
(source: VRPMT)

2.10 Economical Study

- NPV (Net Present Value)

  NPV is a measurement of the profitability of an undertaking that is calculated by subtracting the present values (PV) of cash outflows (including initial cost) from the present values of cash inflows over a period of time.

$$NPV\ (i, N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

- IRR (Internal Rate of Return)

  IRR is a method of calculating rate of return. The term internal refers to the fact that its calculation does not incorporate environmental factors (the interest rate or inflation). When NPV equal to 0 then IRR used for determine the interest in certain level which would make profit.

$$IRR\ =\ i_1 + \frac{NPV_1}{NPV_1 - NPV_2}(i_1 - i_2)$$

- PP (Payback Periods)

  Payback periods is a time for recover the money which already invest in a project.

$$PP = \sum_{t=0}^{N} Ft\ (1+i)^{-t} \geq 0$$

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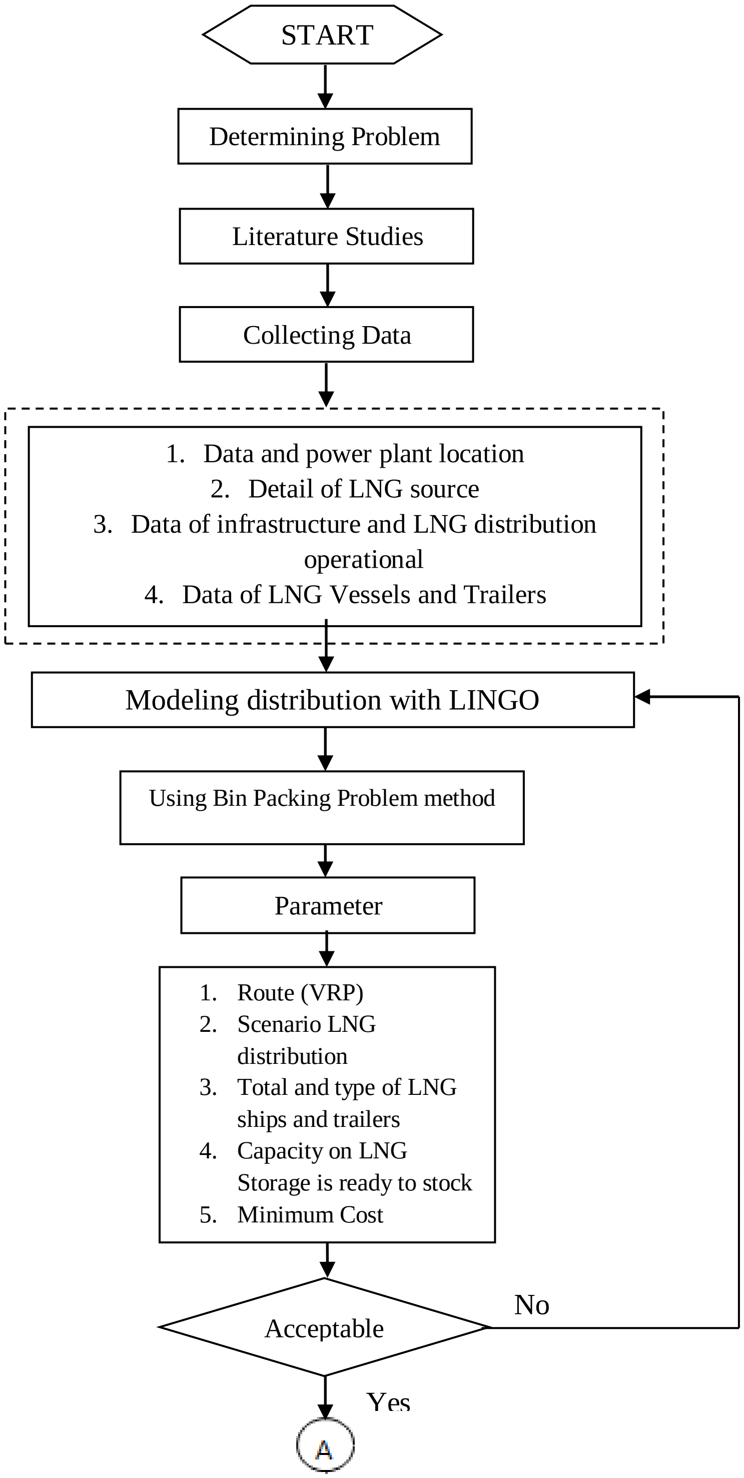
CHAPTER III
METHODOLOGY



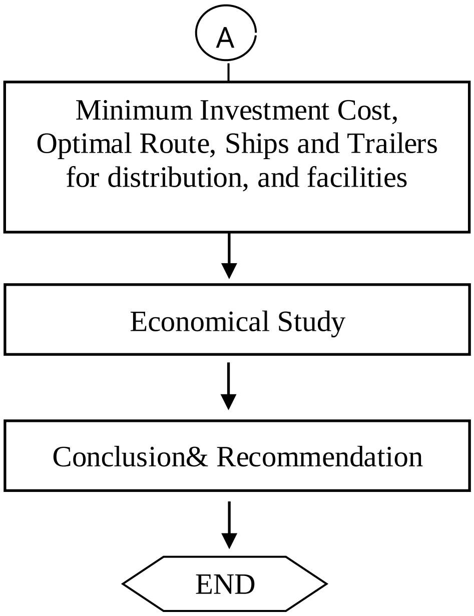


Figure 3. 1 Methodology Flowchart of Bachelor Thesis

Steps are being made to complete the thesis on Optimization LNG Distribution for power plants in Riau Islands with Bin Packing Problem method are:

3.1 Determine the Problems

It is in this stage will find out current conditions and problems that may be the case, so it can be determined whether there is a problem that deserves to be completed by the end of the task or not. The problem can be known through observation, dig up information that exists today or through existing statistical data and its tendency in the future. At this stage, the goal of writing tasks known to the end. In this thesis, the problem will be discussed in the Technical and Economical assessment of mini LNG power plants in the Riau Islands

3.2 Study Literature

The next step after it is already known is the study of literature. At this stage, all matters relating to the problems should know and learn, so that it can give you an idea what to do to solve these problems. Literature studies can be done by reading a book, paper, or journals that relate to solving it.

3.3 Collect Data

After conducting a study of the literature is able to figure out how to solve the problem or steps to achieve the goals. The next step is the collection of data which at this stage, the data to support about problems and decision for methods used, collected to do further analysis. At this point, we collecting such as the main data which can support the problem with the certain method. For the optimization problem, the writer must be collecting electricity needed, location, the capacity will be supplied, the LNG resource, LNG vessel that feasible to use, and the trucks for distribution to every power plants.

3.4 LNG Vessel Selection

LNG ship is commonly used to distribute LNG on a medium or far voyage. There are various LNG type of capacity, is generally divided into four groups, namely the group of vessels capacity is very large (200,000 m3), a large capacity (125,000 m^3, 138.000 m^3, 145,000 m^3), the standard capacity (75,000 m^3), small capacity ships (under 40,000 m^3). For long distance LNG distribution with great demand will be more effective with the use of large capacity vessels, in contrast to the relatively close distance LNG distribution and small demand will effectively use small capacity ships. In this case, the optional of a vessel are 12.000 m^3, 7.500 m^3, and 5.000 m^3. LNG Vessel categorized as a special vessel that has standardization of size to fulfill the demand and also the suitable for the sea voyage.

3.5 LNG Trailer Selection

LNG trailer is used to distribute LNG on the upland. In this case, the writer had chosen two sizes of the trailer from Chart Inc. which ST-12700 and ST-16300 as the transportation upland. These trailers are vacuum-insulated, cryogenic semi-trailers designed specifically for transporting LNG over a long trip. For the composition, usually, it was contained at least 93% methane for balancing the condition over the trailer.

3.6 Modeling of distribution with LINGO

LINGO is a comprehensive tool designed to make building and solving Linear, Nonlinear (convex & not convex/Global), Quadratic, Quadratically Constrained, Second Order Cone, Semi-Definite, Stochastic, and Integer optimization models faster, easier and more efficient.

3.7 Bin Packing Problem

Bin packing is the problem of trying to find a set of objects to pack into containers (or bins). The objects have weights (or volumes), and each container has a capacity, which is the total weight (or volume) the container can hold.

3.8 Vehicle Routing Problem (VRP)

The vehicle routing problem (VRP) is a combinatorial optimization and integer programming problem seeking to service a number of customers with a fleet of vehicles. Proposed by Dantzig and Ramser in 1959, VRP is an important problem in the fields of transportation, distribution, and logistics.

3.9 Economical Study

Conducted to find out the possibility of LNG distribution pattern system is achieved or not, in terms of a technical and economical side. By the way, do the analysis of the feasibility of the system with parameters are NPV, IRR, and PP.

3.10 Conclusion & Recommendation

The expected conclusions from this bachelor thesis are found the optimized the LNG distribution for fuel in Riau Islands power plants and determine the proper routes with efficiently without deny the investment cost.

CHAPTER IV
DATA ANALYSIS

4.1 General

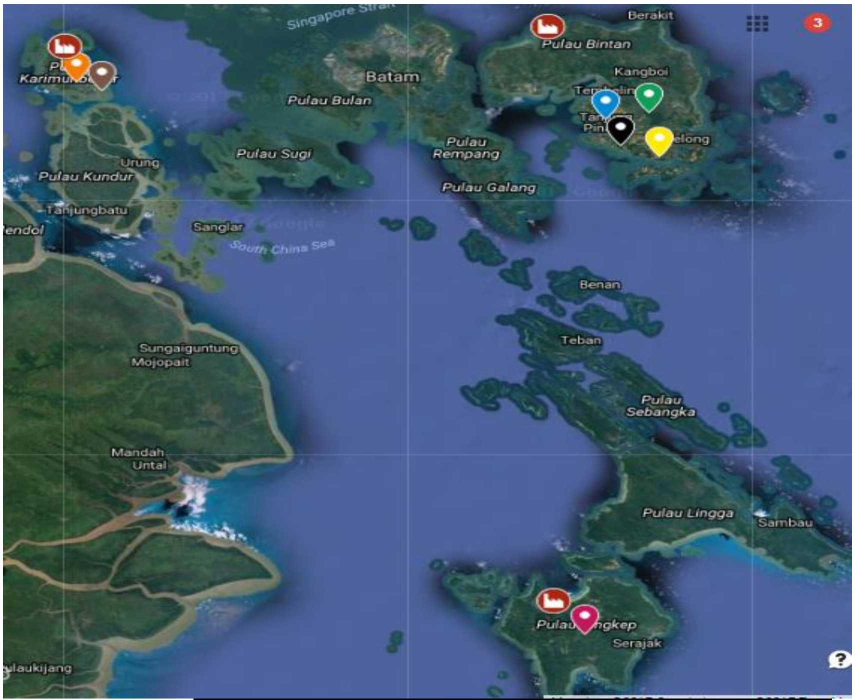
Utilization of natural gas for domestic needs have been enshrined in the regulation of the Minister of Mineral Resource (ESDM) the number 37 by 2015. One of the priorities of the national natural gas usage on electric power supply sector and industry which uses natural gas as fuel. Significant development of the electric power at the region of West Indonesia is in the province of Riau Islands with a total of 491.2 MW development for all types of power plants, which will be realized in the year 2024. To fulfill the needs of gas used as a fuel for power generation in the province of Riau Islands, plan of gas supplied from Arun located in Blang Lancang, Lhokseumawe Aceh, with a production capacity of 12.5 MTPA or of 27,500,000 m3 per year.

Over all the plant which is in the province of Riau Islands there is 3 point spread from the total of 16 power plants that will be in supply. The first, Karimun Island which has five power plants with a total capacity of 111,4 MW equals 356.480 m3 of LNG. The second, Dabo Singkep Island which has two power plants with a total capacity of 30 MW is equal to 96.000 cubic meters of LNG. The third one namely Bintan Island has 9 power plants with a total capacity of 349.8 MW equals 1.119.360 m3. Optimization distribution of LNG to meet the needs of the entire power generation using LNG ship type BCS with the variation of size of 5.000 m3, 7.500 m3, 12.000 m3. For the route, the ship's size and the size of the LNG terminal receiver was selected through a process of optimization.

4.2 Collecting Data

4.2.1 Identification of Power Plants and Receiving Terminal

In this thesis, discuss distribution power plants in Riau Islands. With its three divided areas namely Bintan Island, Karimun Island, and Dabo Singkep Island with each region consists of 5 power plants, 2 power plants, and 9 power plants. Layout and power plants can be seen in Figure 4.1 below.



PLTD AIR RAJA	142,4 MW
PLTD BUKIT CAROK	44,4 MW
PLTD SUKA BERENANG	84,6
PLTMG TANJUNG PINANG	75 MW
PLTU TANJUNG BALAI KARIMUN	67 MW
PLTMG DABO SINGKEP	30 MW
PLTD KOTA LAMA	47,8 MW

Figure 4. 1 Power plants in Riau Islands

In Riau Islands is divided into three locations. First, Bintan Island consists of 9 power plants with total power 349.8 MW. And 9 power plants are PLTD Air Raja, PLTD Air Raja (SW), PLTD Air Raja (SW), PLTMG MPP Tanjung Pinang, PLTMG Tanjung Pinang, PLTD Kota Lama, PLTD Kota Lama (SW), PLTD Suka Berenang, dan PLTD Suka Berenang (SW). The second, Karimun Island consists of 5 power plants with total power 111.4 MW. 5 power plants are PLTU Tanjung Balai Karimun-1, Tanjung Balai Karimun-PLTU 2, PLTG/MG of Tanjung Balai Karimun Peaker, PLTD Bukit Carok dan PLTD Bukit Carok (SW).The third, Dabo Singkep Island consists of two power plants with a total power of 30 MW. Two power plants are PLTMG Dabo Singkep and PLTMG Dabo Singkep-1.

Based on the location of the plant that has been described, will be receiving as many as 3 terminals to receive each supply for each location. The determination of the location and number of terminals depending on the location of the plant so that the ideal of every location can do the LNG unloading easily and should be close to the sea or the coast.

4.2.2 Identification of Arun LNG

Indonesia LNG refinery currently exists in 4 locations in Bontang (East Kalimantan), Arun (Aceh), Tangguh (West Papua) and Donggi Senoro (Central Sulawesi). In this case, determined that LNG refinery has been analyzed as a supplier of LNG for power generation in Riau Island is Arun LNG. Source of LNG were selected based on location tend to be closer to the demand that was in the Riau Island (Figure 4.2). The refinery's production capacity exceeds the demand in which the capacity of the refinery Arun 12.5 MTPA (4)

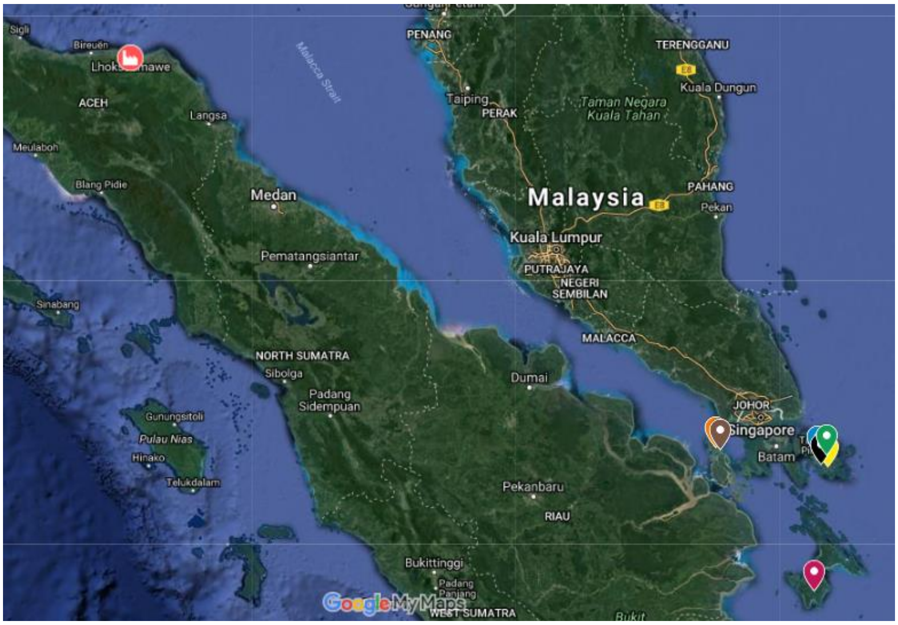


Figure 4. 2 Location of Arun LNG and Power Plants

Identification of the distance between the refinery with the receiving terminal needs to be performed to calculate the estimated time of ship voyage. After learning the location of each receiving terminal and the location of the refinery will be determined as:

- Arun LNG – Bintan Island: 591,51 nm.
- Arun LNG – Karimun Island: 527,87 nm
- Arun LNG – Dabo Singkep Island: 658,23 nm

4.2.3 Identification of Power Plants location

In this case, the location of power plants is divided into locations that are Bintan Island, Karimun Island, and Dabo Singkep. And each of the locations there is power plants that will be in supply by using a trailer already set. Based on an analysis of the location of the receiving terminal that is closest to the sea and there are 3 locations that are ready to accept. To know estimated mileage of each location between power plants then created a matrix of distances between power plants as follows.

Table 4. 1 Distance Matrix Bintan Island (km)

	RT 1	PLTD AIR RAJA	PLTMG TANJUNG PINANG	PLTD KOTA LAMA	PLTD SUKA BERENANG
RT 1	0	73.9	82.7	58.3	87.5
PLTD AIR RAJA	73.9	0	30.6	11.9	28.1
PLTMG TANJUNG PINANG	82.7	30.6	0	23.95	12.5
PLTD KOTA LAMA	58.3	11.9	23.95	0	24.3
PLTD SUKA BERENANG	87.5	28.1	12.5	24.3	0

Table 4. 2 Distance Matrix Karimun Island (km)

	RT 2	PLTU/PLTMG TANJUNG BALAI KARIMUN	PLTD BUKIT CAROK
RT 2	0	23	16.3
PLTU/PLTMG TANJUNG BALAI KARIMUN	23	0	8,4
PLTD BUKIT CAROK	16.3	8,4	0

Table 4. 3 Distance Matrix Dabo Singkep Island (km)

	RT 3	PLTD TANJUNG BATU
RT 3	0	20.48
PLTD TANJUNG BATU	20.48	0

4.2.4 Identification of Barge Container Skid (BCS)

In this case, the distribution of LNG from the refinery to the receiving terminal is planned using a Barge Container Skid (BCS) with a size of 12,000 m3, 7.500 m3, and 5,000 m3. The BCS is suitable for the distribution of LNG on the islands of Indonesia, because of the number of nodes each distance is not too far and demand of each node is relatively small. And the BCS is also an option due to being one of the select because good to support development to areas closer to the waters and hard to reach for other water transport. On the other side of the BCS has also become a solution for the transportation of LNG is cheaper than other LNG ship and at the same time can bring an amount of larger volume. The BCS also had a low draught and a good maneuver makes it possible to ship transits in the area of swallow river contour and coastal areas than conventional LNG ships in general.

There are several bathymetries in every location that BCS will pass through and receiving terminal already aimed below:

On figure below showed that the sea depth around Arun, Lhokseumawe is 9 meters, so it is possible for the BCS for loading LNG to the tank which is the depth of the BCS is around 6,6 meters. And Karimun Island is around 10 meters, Bintan Island is around 10 meters, and Dabo Singkep Islands is around 10 meters. (14)

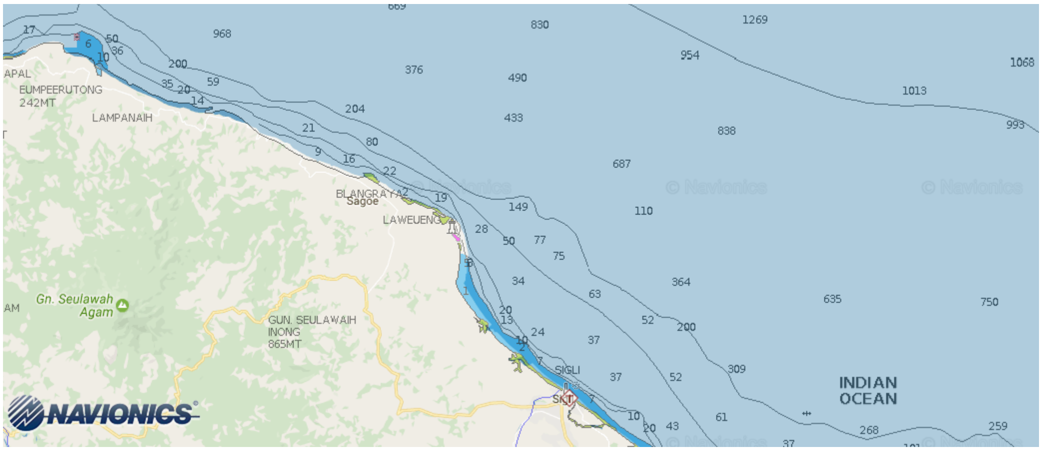


Figure 4. 3 Bathymetry in Arun, Lhokseumawe

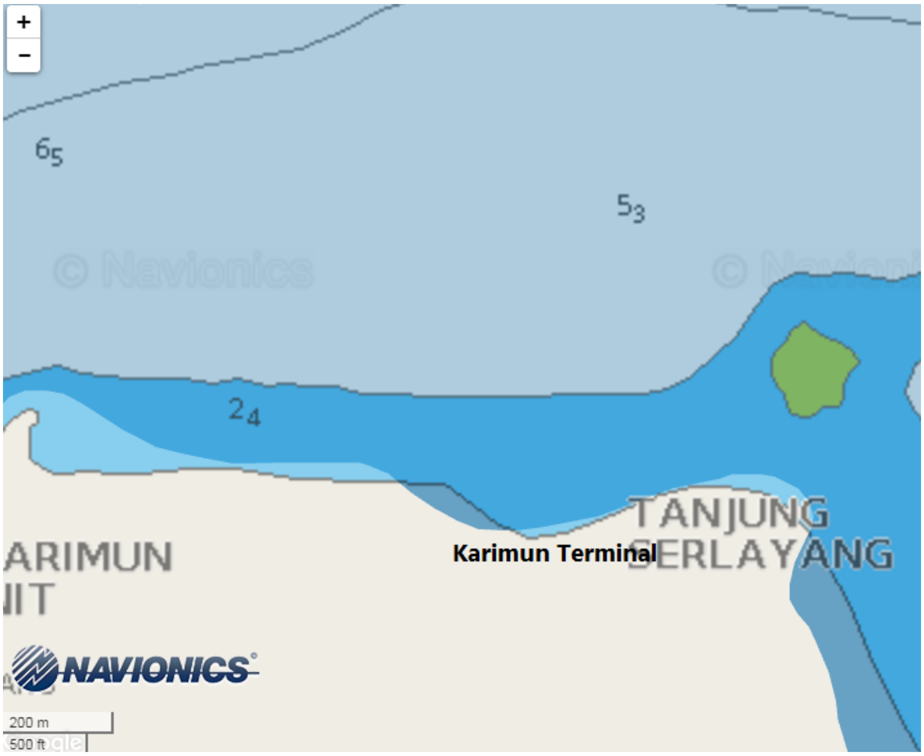


Figure 4. 4 Bathymetry in Karimun Island

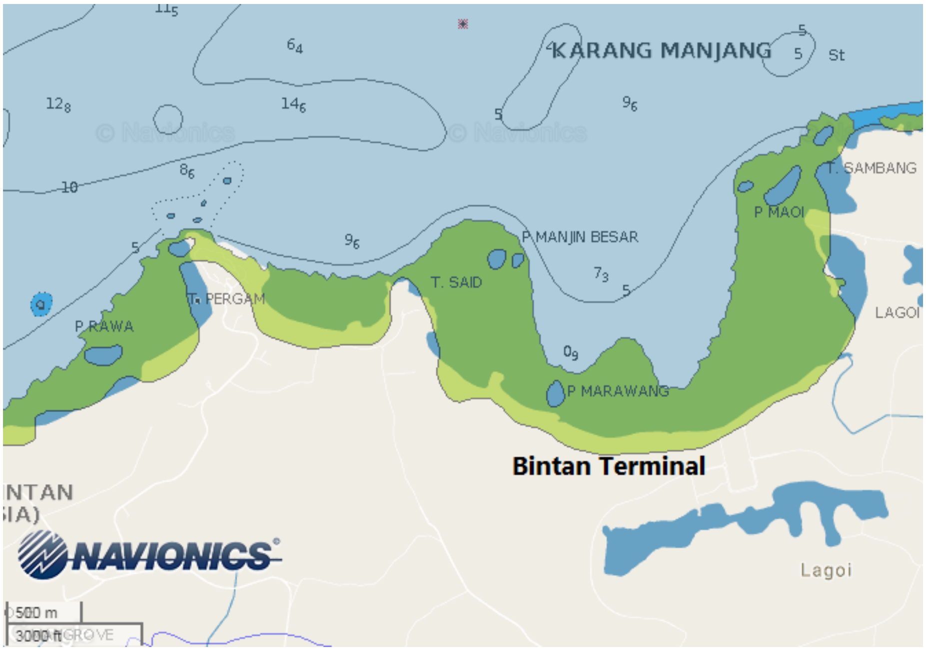


Figure 4. 5 Bathymetry in Bintan Island

Figure 4. 6 Bathymetry in Dabo Singkep Island

Based on Artana, Ketut Buda, Sugiono. 2006 about LNG Technology, there are several factors calculation of transport costs and process optimization. The required data in the calculation of transport costs and process optimization are:

1. Tank capacity on ship
Tank capacity of ship effect on the number of nodes that will be served. The larger the capacity of the ship's tanks, then it can bring more of amount LNG. However, the larger the tank, the ships have an impact also on the size of ships and the expensive charter ships.

2. The speed of the vessel
At the same distance, the ship with higher speeds will require less time to reach a destination. The round trip of ship will be getting decrease

and have an impact on sized of smaller receiving terminal as well as the operational time of the vessel being less.

3. The capacity of the pump
On unloading process, LNG distribute from the ship to the receiving terminal by the pump. Pump capacity determines the time of LNG unloading process from the ship to the receiving terminal. So that later will also affect round trip of the ship.

4. Fuel consumption per day
In the calculation cost of the ship, fuel is an important component. In contrast to the large-sized LNG vessel where the main propulsion engines mostly use a steam turbine or gas turbine, at BCS, the prime mover machines still use diesel engines. Therefore, the fuel on the BCS still use HFO or MDO.

5. Ship Charter rate
Ship is an asset with substantial value. On the problems of distribution using ships, can be obtained by build the new one or charter. Charter ship of course also included in the calculation of the cost of transportation. So that it becomes a useful support data to calculate the transportation costs. The data will be described later.

4.3 Determine the Area for distribution

In this thesis, the distribution area divided into 3 different locations and based on data already accumulated the conclusion that the power plants located in Riau Island into three locations to be in supply. By determining the area of distribution or the location of the destination, it will facilitate the sharing of LNG demand from each location.

For the first location is a whole power plant who were in the Bintan Island which is central to economic activities in Tanjung Pinang town. Assuming using one receiving terminal for distribution with 9 total power plants of 349.8 MW which is equivalent to the needs of 3109.3 m3 of LNG per day.

The second is the location for the entire power plant located in Karimun Island as tourism area which is being developed rapidly for the Riau Island province's economy. Assuming using one receiving terminal for distribution 5 power plants with a total power of power plants amounted to 111.4 MW equivalent to the needs of 990.22 m3 of LNG per day.

For the third location is Dabo Singkep Island for the rest of distribution. Assuming using one receiving terminal for distribution two power plants with a total power of 30 MW power plants which is equivalent to the needs of 266.67 m3 of LNG per day.

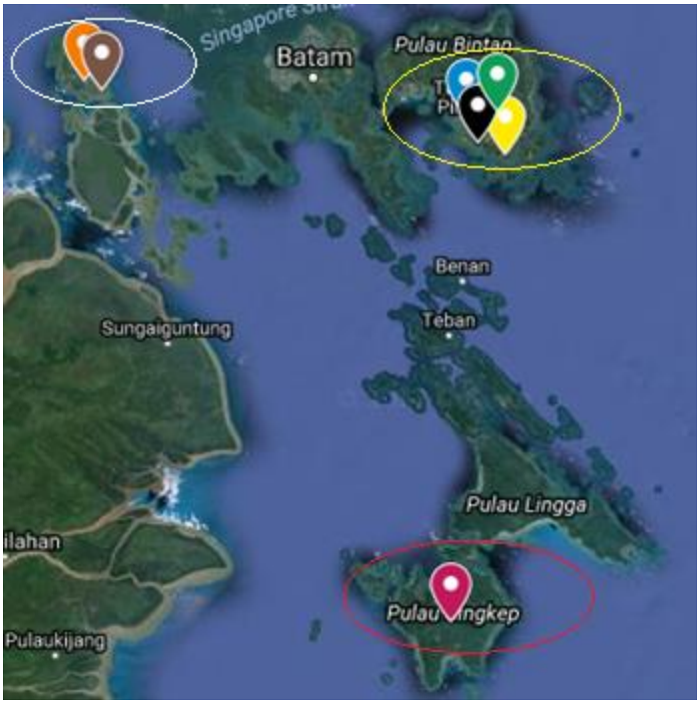


Figure 4. 7 Area of distribution will be supplied

4.4 Determine the cost of transportation

4.4.1 Voyage Cost

The cost of the voyage is the costs for carrying the goods from the port of origin to the port of destination. Variables in calculating the cost of the ship include fuel costs, as well as the port cost. The cost of the voyage, route x with ship y can be calculated by summing the costs of fuel and needs one-time round trip and also the port cost for that route.

The ship's fuel needs y to do one time round trip with a route x is a multiplicative function between round trip route x with ship y

Round trip day is not only a time for ships sailing only or commonly called sea time route x with ship y but also the time of unloading in the port or port time. Sea time is the time it takes to travel the route the ship speed route x with ship y.

Port time is the time required in the process of loading and unloading of LNG. LNG loading is done in source LNG while unloading LNG moved from the ship to the receiving terminal. Time of loading LNG to the ship is assumed to equal to the time of unloading by using pumps on the ship. Then to calculate the port time can use the capacity of LNG on the ship y and the capacity of the pumps on the ship y.

For the port, charge consists of the costs of docking fees, berth, the cost of guide ship and etc. Cost refers to the price of the services ship PT. Indonesia I Port in 2010 due to the location of the distribution area of the incoming Port Indonesia. (16)

Table 4. 4 Port Cost

Port Cost Service		
Berth Service	Rp 95.36	each GT
Mooring Service	Rp 92.84	each GT
Guide Service		
-permanent	Rp 67,265.00	Ship/move
-variable	Rp 20.64	GT/Ship/move
Tug Service		
a. 2001 – 3500 GT		
-permanent	Rp 546,260.00	Ship/hour
-variable	Rp 10.00	GT/Ship/hour
b. 3501 – 8000 GT		
-permanent	Rp 771,456.00	Ship/hour
-variable	Rp 10.00	GT/Ship/hour
c. 8001 – 14.000 GT		
-permanent	Rp 1,299,100.00	Ship/hour
-variable	Rp 10.00	GT/Ship/hour
d. 18.001 – 23.000 GT		
-permanent	Rp 2,860,000.00	Ship/hour
-variable	Rp 10.00	GT/Ship/hour

4.4.2 New Ship of BCS

On this problem of distribution is planned a new ship Barge Container Skid. For determining the new ship for certain route and area, there are many factors should be provided to make sure the ship will be fine. Before the ship is built, the data of demand to provide the project is needed. So, the ship can be built depending on demand. In this case is LNG demand for power plants in Riau Islands. And, the information of voyage must be completely done to make sure that the ship is possible to distribute the LNG demand with a certain route. After the data and information are completed, then the project management can give the recommendation to build a number of ships needed for this project. Of course, these ships are fixed to distribute for a long term condition until the project is done. According to Stopford (2007), in general, there are three types in charting ship, there are voyage charter, time charter, and bare boat charter. Charter of a ship depends on the type of ship and the owner of the ship (ship owner) and charterer. (8)

Voyage charter is the ship charter system between the owners of the ship (ship owner) and charterer by the routes of transport or the number of ships to travel. On the voyage charter, boat owners provide transportation for cargo from some or all of the space ship unloading from port A to port B with a fixed price per ton payload. In this type, generally, ship owners responsible for the entire cost of loading and unloading fee or ship owners are also responsible for managing the operations of the ship as well as for the voyages.

A time charter is the ship charter system between the owners of the ship and charterer within a certain period. Charter fees are usually in the form of rents ship by per day or per month. In this case, charterer responsible the costs of fuel, the cost of the port facilities, and other costs with the total charge. While ship owner remains operational risk.

Bare boat charter is the ship charter system between the owners of the ship and charterer where ship owners hand over the ship in conditions of empty. Basically, the ship owner provides the ships and then receive character money from the charterer to cover all the costs. All operating costs, the cost of the ship responsible by the charterer.

In calculating transport costs in one year can be done with the cost of transportation route x with ship y within a year, make the cost of fuel, the cost of the port, the cost of ships to voyage through the routes and ships.

4.5 Determine the cost of the receiving terminal investment

On the distribution of LNG for power plants, LNG from ships before distributing to each power plant either through gas pipes or transported using trucks, LNG handling in advance at the LNG receiving terminal. LNG receiving terminal has facilities for receiving and handling of LNG. These facilities include storage tanks, loading and unloading LNG, the handling Boil of Gas (BOG), LNG pumps, vaporizer LNG regasification units, and a number of other supporting facilities.

4.5.1 Investment on LNG Tank and Land

The size of each terminal of the receiving depends on the time of voyage ships, the size of the ship, and also power plants consumption per day. The power plant needs get larger, then gas consumption for the plant gets bigger. The receiving terminal should be able to supply gas at least with need every capacity of the plant. The receiving terminal should be able to accommodate LNG at least for one round trip of the ship. (15)

Table 4. 5 Details cost receiving terminal facilities and transportation

No	Item	Unit	Unit Price (USD)
1	BCS LNG V1	per unit	$ 3,500,000.00
2	BCS LNG V2	per unit	$ 2,500,000.00
3	BCS LNG V3	per unit	$ 1,500,000.00
4	Trailer LNG V1	per unit	$ 28,000.00
5	Trailer LNG V2	per unit	$ 31,000.00
6	Land Investment	per meter	$ 143.00
8	LNG Offloading and send out station	per set	$ 2,600,000.00
9	LNG Storage Tank 350	per unit	$ 405,005.00
10	LNG Storage Tank 700	per unit	$ 510,010.00
11	LNG Storage Tank 1200	per unit	$ 717,160.00
12	Cyrogenic Pipe	per meter	$ 770.00
13	Jetty Facilities	per meter	$ 13,300.00
14	LNG Pump	up to 2,5 m3/h	$ 13,500.00
15	LNG Pump	up to 20 m3/h	$ 24,000.00
16	BOG Compressor	per set	$ 93,000.00
17	Vaporizer	per set	$ 40,000.00
18	Supporting Building	per unit	$ 77,000.00

4.6 Determine the Total Ship

After collecting all the data needed for the input, after that the data ready to process. Several data required for the process are the ship's capacity were three type of size 12.000 m3, 7.500 m3, and 5.000 m3. We need to determine every cost needed in each ship already aimed. And another data is the demand per day in every location are Karimun 990,22 m3, Dabo Singkep 266,667 m3, and Bintan 3109,33 m3. After that, the total of demand is 4366,22 m3 which are per day need to be supplied. From the modeling using Lingo, data will be processed according to every input data needed and the output will be the total and capacity of ships already selected. For the input data as the figure below the required for a process are the total destination are three locations, the time window, in this case, is 24 hours, the ship's alternative for selection are three variations.

wj = demand of LNG j,

c = capacity of each ship,

All these should be arranged for every demand of LNG to each ship no exceed c as the capacity of the ship and the number of ships used as a minimum as a limitation. Where the formula of the problem in mathematical is,

$$\text{minimize} \quad z = \sum_{i=1}^{n} y_i$$

$$\text{subject to} \quad \sum_{j=1}^{n} w_j x_{ij} \le c y_i, \quad i \in N = \{1, \dots, n\},$$

$$\sum_{i=1}^{n} x_{ij} = 1, \quad j \in N,$$

$$y_i = 0 \text{ or } 1, \quad i \in N,$$

$$x_{ij} = 0 \text{ or } 1, \quad i \in N, j \in N,$$

where,

y_i = 1 if ship *i* is used;
0 otherwise,
x_{ij}= 1 if demand *j* is assigned to ship *i*;
0 otherwise.

Table 4. 6 Route for ship

Ship	Route
V3	1 – 2 – 1
V3	1 – 3 – 4 – 1

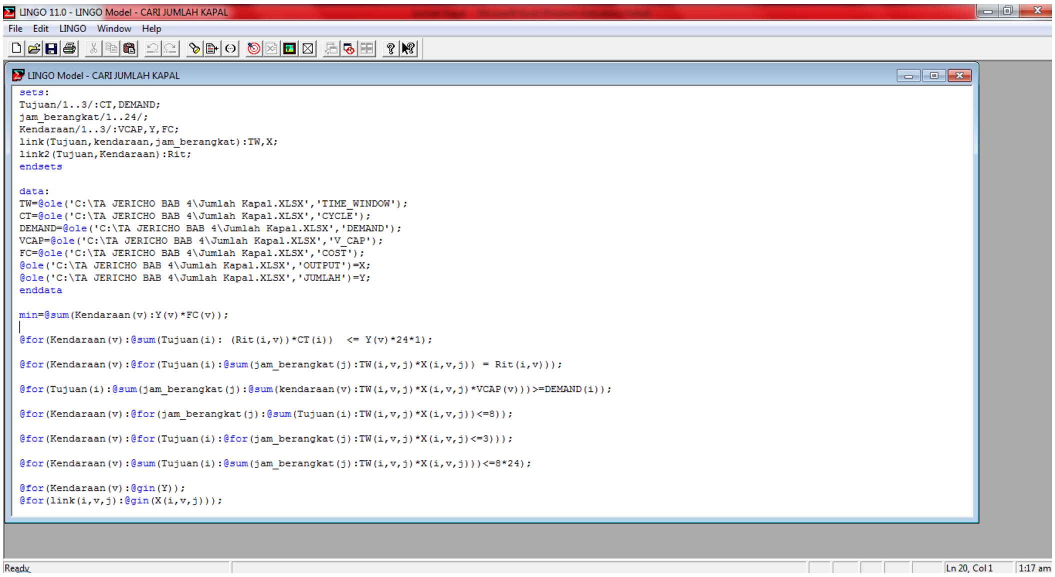


Figure 4. 8 Lingo Model for ships

After input all the data, the Lingo integrated with the Excel already made with every data needed. The output is two ships of 5.000 m3 need for distributing the LNG need for Riau Island, where divided into Karimun, Dabo Singkep, and Bintan Island.

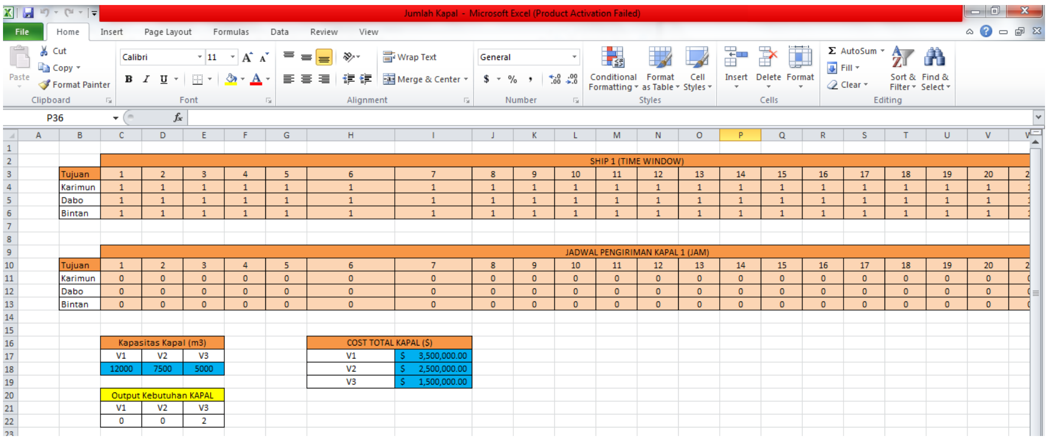


Figure 4. 9 Excel output for total of ship needed

4.7 Determine the Network of ships

From the modeling with Lingo above, the output data are two ships of 5.000 m3 needed for distributing the LNG demand in each location. The first network is the first ship distributing the LNG from Arun Refinery to Bintan Island. The second network is the second ship distributing the LNG from Arun

Refinery to Karimun Island and after unloading the LNG demand at Karimun Island, the ship continues the voyage to Dabo Singkep Island for the rest demand.

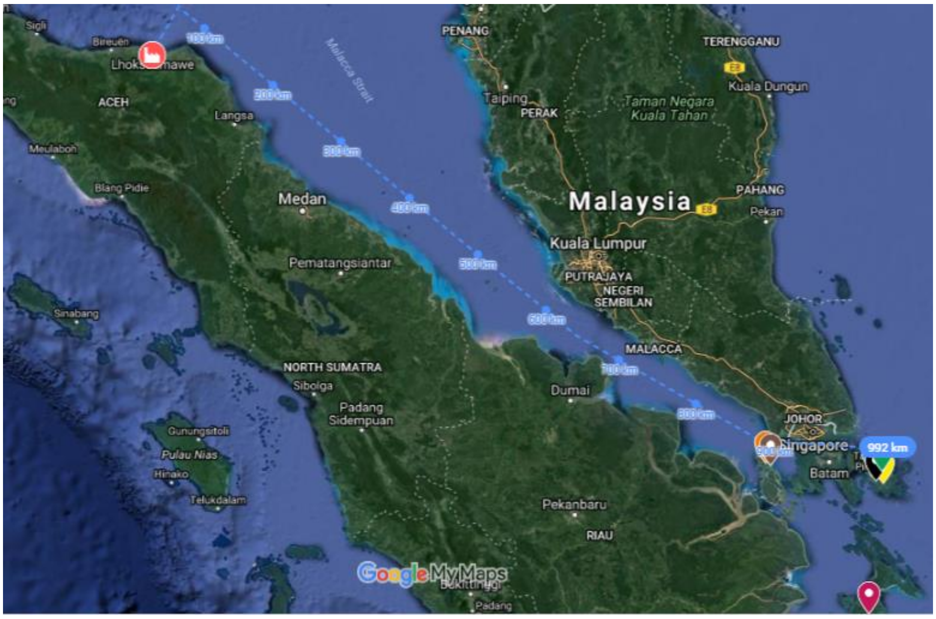


Figure 4. 10 Distributing for Bintan Island by one BCS of 5.000 m^3

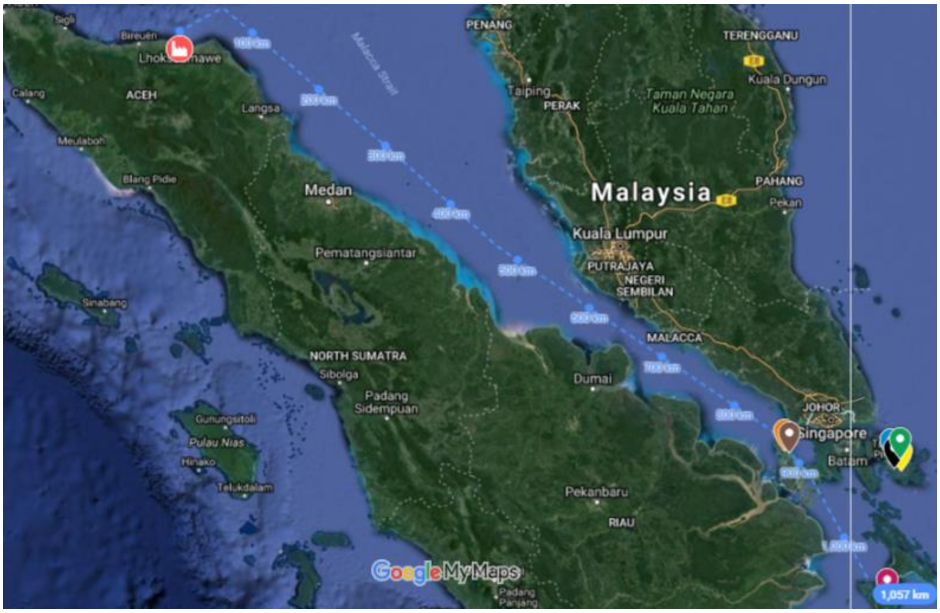


Figure 4. 11 Distributing for Karimun and Dabo Singkep Island by one BCS of 5.000 m^3

4.8 The Mathematical Calculation

To create the VRP modeling, there are steps need to be obtained. The steps assume the variable will be used, identify the decision variable, purpose function will be achieved, and constraints. Then the goal is to determine the optimum route. In this thesis, the optimizer will be work on the distance every power plant for distributing LNG demand and consider the trailer capacity, LNG demand every power plants, and distance every power plants. The model has been done on LINGO program.

4.8.1 Parameter Input

In this model there are parameters already known and ready for input are,

Information:

U	= sequence of places (*i, j, k*)
Distance	= distances between places (d_i, d_j, d_k)
X	= variable of decision (biner)
Node	= total of node

4.8.2 The Constrains for optimization

The constraint for this model depends on demand every power plants needed, numbers of trailers, and capacity of the trailer. This constraint showed that every power plants will be visited once by one trailer. If the power plant not visited by the trailer, the result is 0. In the other hand, the power plant visited by the trailer is 1. The results of the calculation will be in Biner.

Purpose Function:
Min = $\sum_i \sum_j (distance_{ij} \quad x \quad X_{ij})$

The purpose function is to make the minimum cost by the distance that already made. From by minimum the distance of the route, of course, will reduce the cost.

Constraint 1 (leave place)
$\sum_i \sum_j X_{ij}$=1 $\quad \forall_i$ i≠j

The trailer will leave the first place and will go to the next destination and not going back.

Constraint 2 (enter place)

$\sum_i \sum_j X_{ij}$=1 $\forall_j$ j≠i

The trailer will enter the place and not enter the same place, but the next place, so the trailer only once to visit the next place.

Constraint 3 (transportation can't back to the previous place)

Node*X_{ij}+ U_i - U_j ≤ (Node-1)

The trailer already enters the place and can't go back to the previous place and will enter the next destination.

Constraint 4

Biner

The output will be in Biner value which is 1 or 0 for set it.

Below is the Bintan output of Lingo process,

```
sets:
city/1..5/:Q,U;
CXC(city,city):Dist,X;

endsets
```

Figure 4. 12 Structure of sets

The figure above showed that the sets and the endset for the Bintan Island on Lingo where the destination is five places.

```
DATA:
Q= 0 60.27 31.74 20.23 35.81;
DIST=
0          1.8475     2.0675     1.4575     2.1875
1.8475     0          0.765      0.2975     0.7025
2.0675     0.765      0          0.59875    0.3125
1.4575     0.2975     0.59875    0          0.6075
2.1875     0.7025     0.3125     0.6075     0;
VCAP = 61.7;
ENDDATA
```

Figure 4. 13 The data of place

The figure above showed that the data of LNG demand each place. Because this model is determined by the minimum distance to travel so the output will show the Biner 1 or 0 for routing.

```
Min=@sum(CXC(i,j):Dist(i,j)*X(i,j));

@for(city(k)|k#GT#1:@sum(city(i)|i#NE#k #AND# (i#EQ#1 #OR# Q(i)+Q(k) #LE# VCAP):X(i,k))=1);

@for(city(k)|k#GT#1:@sum(city(j)|j#NE#k #AND# (j#EQ#1 #OR# Q(j)+Q(k) #LE# VCAP):X(k,j))=1);

@for(city(k)|k#GT#1:@bnd(Q(k),U(k),VCAP));

@for(city(k)|k#GT#1:@for(city(i)|i#NE#k #AND# i#NE#1:
U(k)>=U(i)+Q(k)-VCAP + VCAP*(X(k,i)+X(i,k))-(Q(k)+Q(i))*X(k,i)));

@for(city(k)|k#GT#1:U(k)<=VCAP-(VCAP-Q(k))*X(1,k));

@for(city(k)|k#GT#1:U(k)>=Q(k)+@sum(City(i)|i#GT#1:Q(i)*X(i,k)));

@for(CXC(i,j):@bin(X(i,j)));
```

Figure 4. 14 Constrains and the minimum objective

The figure above showed constraints will be applied to the Lingo and the output will be the minimum value and the sum means for the totals.

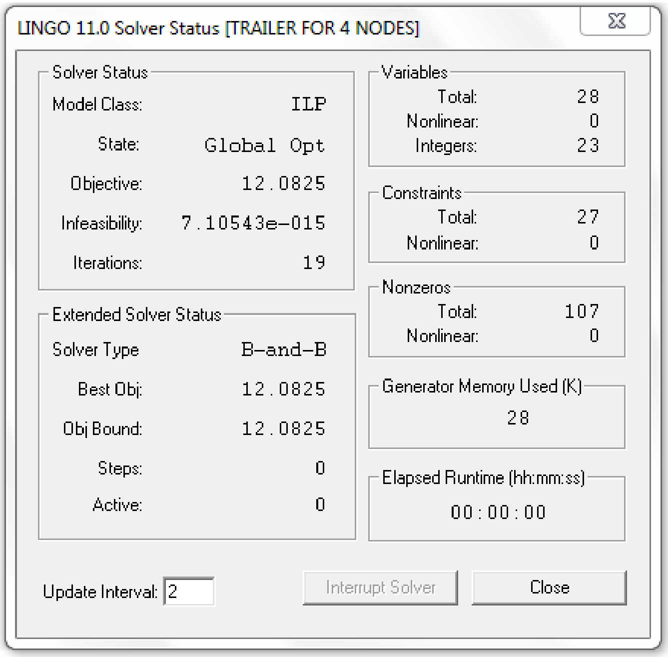


Figure 4. 15 Solver status

The figure above showed that the solver status for the Bintan Island. So, above showed the process of determining the sets, the end sets, data of demand, distances, constraints, and the solver result. Another place will be put in the attachment.

4.9 Determine the Total Trailers

For the trailers, already selected from Chart Inc. trailers. Chart Inc. had two sizes of the trailer. After collecting all the data needed for the input and data ready to process. Several data required for the process are the trailer capacity were two type of size are 48,1 m3 and 61,7 m3. We need to determine every cost needed in each trailer already aimed. And another data is the demand per day in every location is PLTD Air Raja 1265,8 m3; PLTMG Tanjung Pinang 666,7 m3; PLTD Kota Lama 424,9 m3; and PLTD Suka Berenang 752 m3. After that, the total of demand is 3109,4 m3 which are per day need to be supplied. From the modeling using Lingo, data will be processed according to every input data needed and the output will be the total and capacity of trailer already selected. For the input data as the figure below the required for a process are the total destination, in this case, are four locations, the time window, in this case, is 24 hours, the trailer alternative for selection are two variations.

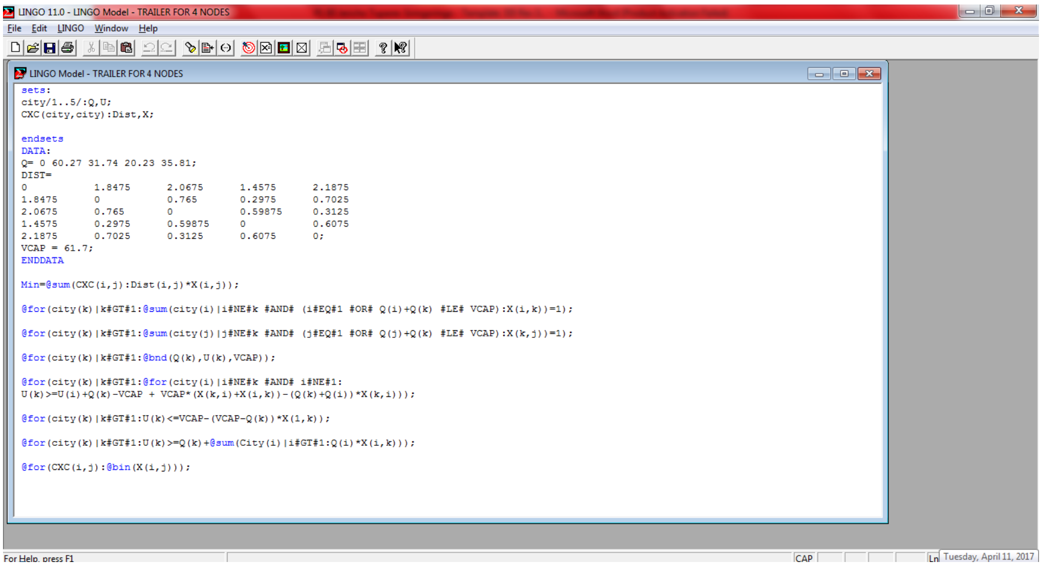


Figure 4. 12 Lingo Model for trailer 4 nodes

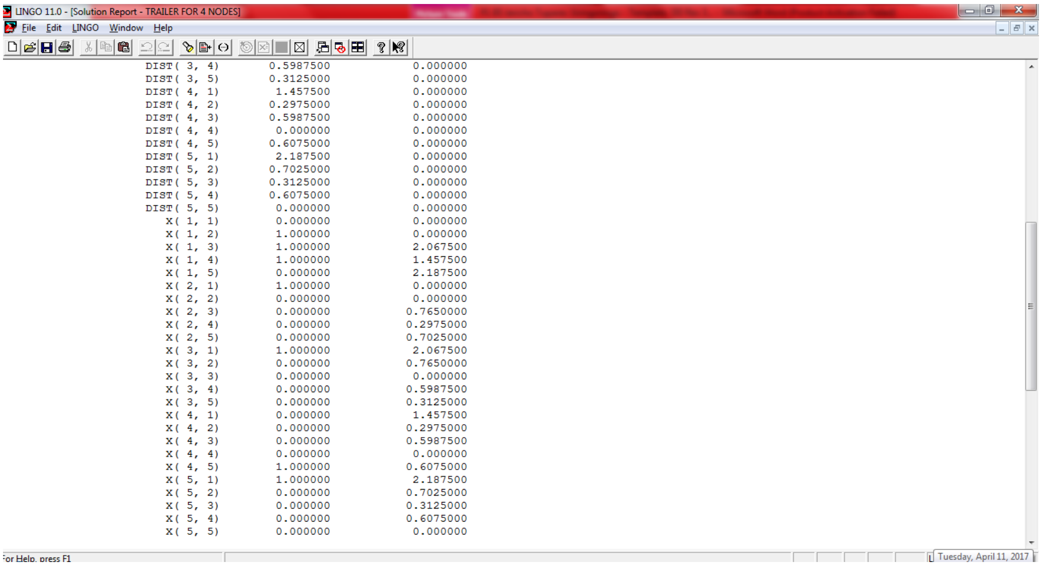
After input all the data, the Lingo process every data needed. The output is 16 trailers of 61,7 m3 are need for distributing the LNG need for Bintan Island. The highest demand on PLTD Air Raja divided by the capacity of the highest capacity of the trailer so the result is trip needed. And for the trip is 21 trips needed.

Calculation: $x = \frac{21\ x\ 3}{\frac{24}{6}}$ = 15.75 ~ 16 trailers.

From the Lingo, the output for routing also be found.

Table 4. 7 Route for trailer in Bintan Island

Trailer	Route
B	1 – 2 – 1
B	1 – 3 – 1
B	1 – 4 – 5 – 1



DIST(3, 4)	0.5987500	0.000000
DIST(3, 5)	0.3125000	0.000000
DIST(4, 1)	1.457500	0.000000
DIST(4, 2)	0.2975000	0.000000
DIST(4, 3)	0.5987500	0.000000
DIST(4, 4)	0.000000	0.000000
DIST(4, 5)	0.6075000	0.000000
DIST(5, 1)	2.187500	0.000000
DIST(5, 2)	0.7025000	0.000000
DIST(5, 3)	0.3125000	0.000000
DIST(5, 4)	0.6075000	0.000000
DIST(5, 5)	0.000000	0.000000
X(1, 1)	0.000000	0.000000
X(1, 2)	1.000000	0.000000
X(1, 3)	1.000000	2.067500
X(1, 4)	1.000000	1.457500
X(1, 5)	0.000000	2.187500
X(2, 1)	1.000000	0.000000
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	0.7650000
X(2, 4)	0.000000	0.2975000
X(2, 5)	0.000000	0.7025000
X(3, 1)	1.000000	2.067500
X(3, 2)	0.000000	0.7650000
X(3, 3)	0.000000	0.000000
X(3, 4)	0.000000	0.5987500
X(3, 5)	0.000000	0.3125000
X(4, 1)	0.000000	1.457500
X(4, 2)	0.000000	0.2975000
X(4, 3)	0.000000	0.5987500
X(4, 4)	0.000000	0.000000
X(4, 5)	1.000000	0.6075000
X(5, 1)	1.000000	2.187500
X(5, 2)	0.000000	0.7025000
X(5, 3)	0.000000	0.3125000
X(5, 4)	0.000000	0.6075000
X(5, 5)	0.000000	0.000000

Figure 4. 13 Lingo output for route of trailers needed in Bintan Island

For Karimun Island demand per day in every location are PLTU Tanjung Balai Karimun 595,6 m3 and PLTD Bukit Carok 394,6 m3. The total of demand is 990,2 m3 which are per day need to be supplied. From the modeling using Lingo, data will be processed according to every input data needed and the output will be the total and capacity of trailer already selected. For the input data as the figure below the required for a process are the total destination, in this case, are two locations, the time window, in this case, is 24 hours, the trailer alternative for selection are two variations.

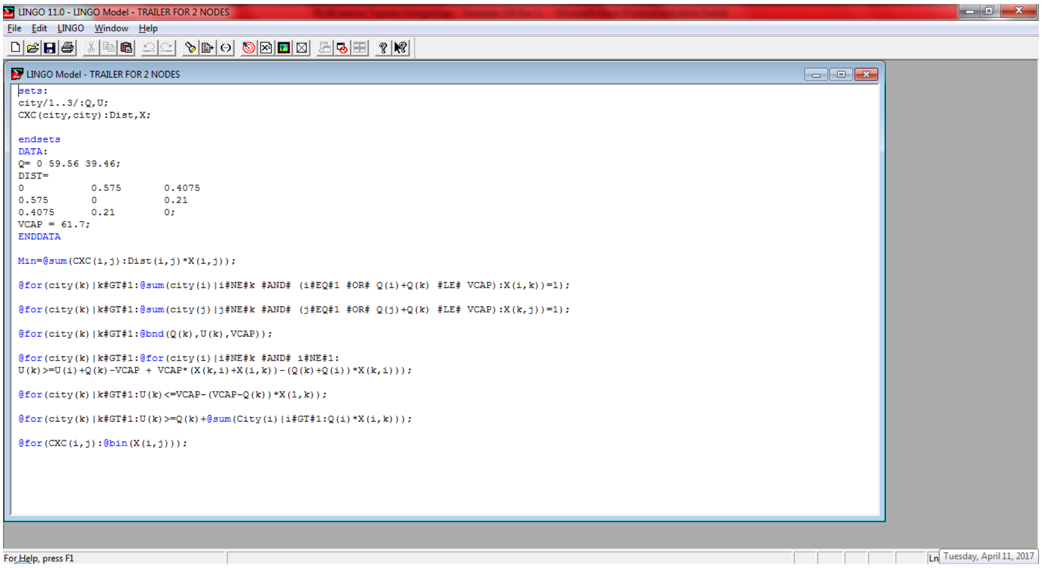


Figure 4. 14 Lingo Model for trailer 2 nodes

After input all the data, the Lingo process every data needed. The output is 4 trailers of 61,7 m3 are need for distributing the LNG need for Karimun Island. The highest demand on PLTD Tanjung Balai Karimun divided by the capacity of the highest capacity of a trailer so the result is trip needed. And for the trip is 10 trips needed.

Calculation: $x = \frac{10\ x\ 2}{\frac{24}{4}} = 3.33 \sim 4$ trailers.

From the Lingo, the output for routing also be found.

Table 4. 8 Route for trailer in Karimun Island

Trailer	Route
B	1 – 2 – 1
B	1 – 3 – 1

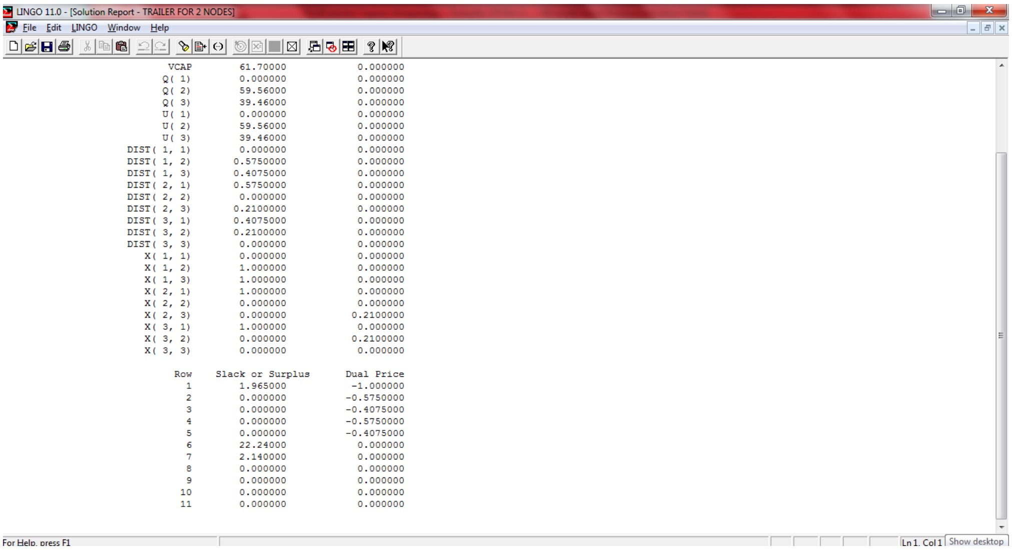


Figure 4. 15 Lingo output for total of trailers needed in Karimun Island

For Dabo Singkep Island demand per day in every location is PLTMG Dabo Singkep 266,7 m3. The total of demand is 266,7 m3 which are per day need to be supplied. From the modeling using Lingo, data will be processed according to every input data needed and the output will be the total and capacity of trailer already selected. For the input data as the figure below the required for a process are the total destination, in this case, are one location, the time window, in this case, is 24 hours, the trailer alternative for selection are two variations.

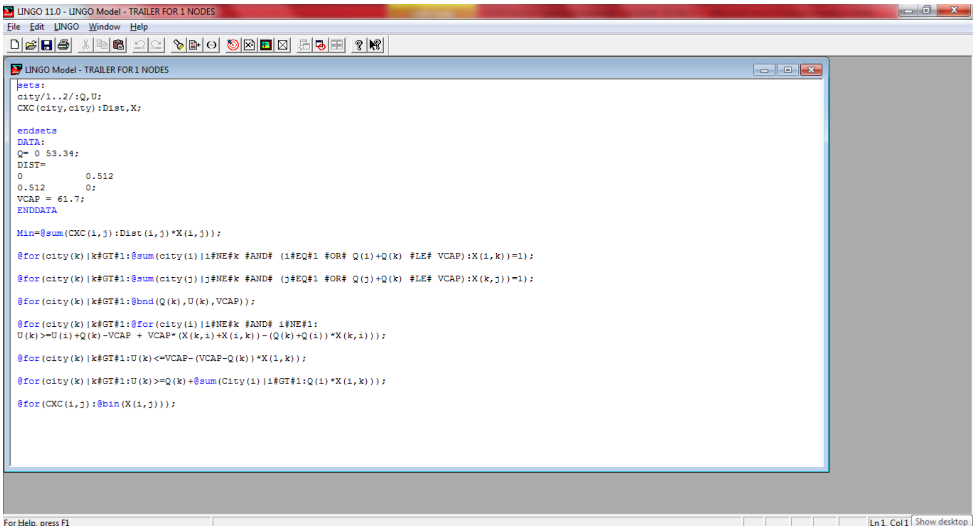


Figure 4. 20 Lingo Model for trailer one node

After input all the data, the Lingo integrated with the Excel already made with every data needed. The output is 1 trailers of 61,7 m^3 need for distributing the LNG need for Dabo Singkep Island.

Calculation: $x = \frac{1\ x\ 5}{\frac{24}{4}}$ = 0,83 ~ 1 trailers.

From the Lingo, the output for routing also be found.

Table 4. 9 Route for trailer in Dabo Singkep Island

Trailer	Route
B	1 – 2 – 1

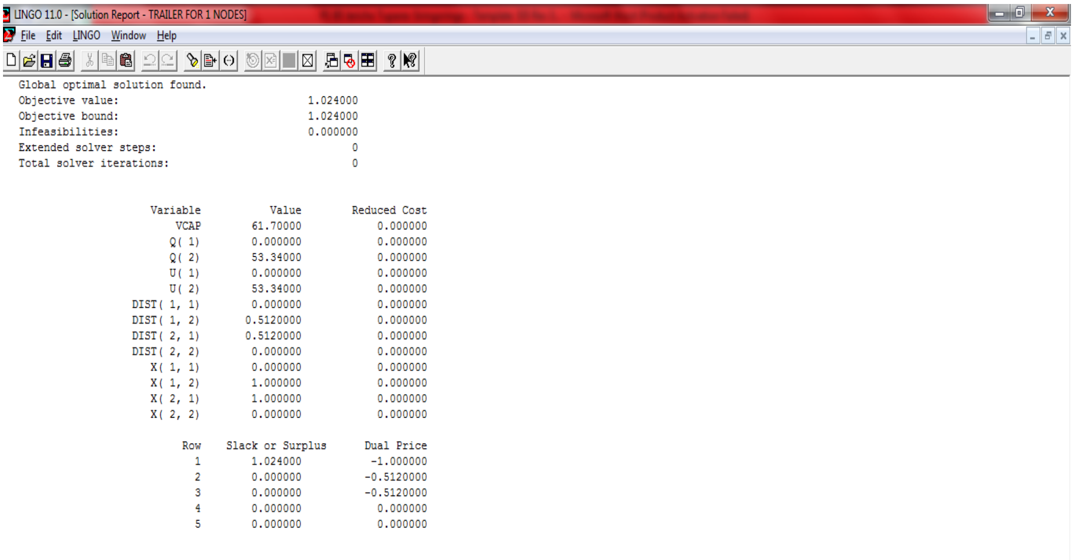


Figure 4. 21 Lingo output for total of trailer needed in Dabo Singkep Island

4.10 Determine Total Cost Every Routes

4.10.1 First Route for Bintan Island

Table 4. 10 Calculating estimation cost for Bintan Island

CAPEX Bintan Island

No	Investment	SPECS	Unit	Unit Price (USD)	Total Price (USD)
1	Cyrogenic Pipe	100	per meter	$ 770.00	$ 77,000.00
2	Jetty Facilities	150	per meter	$ 13,300.00	$ 1,995,000.00
3	Land Investment	5000	per m2	$ 143.00	$ 715,000.00
4	LNG Pump	3	up to 2,5 m3/h	$ 13,500.00	$ 40,500.00
5	LNG Pump	3	up to 20 m3/h	$ 24,000.00	$ 72,000.00
6	BOG Compressor	3	per set	$ 93,000.00	$ 279,000.00
7	Vaporizer	2	per set	$ 40,000.00	$ 80,000.00
8	Supporting Building	1	per unit	$ 77,000.00	$ 77,000.00
9	LNG Offloading and Filling station	1	per set	$ 2,600,000.00	$ 2,600,000.00
10	Electric Power Generator	3	per unit	$ 400,000.00	$ 1,200,000.00
11	Trailer V2 LNG	3	per unit	$ 31,000.00	$ 93,000.00
12	LNG Storage Tank 1200	3	per unit	$ 717,160.00	$ 2,151,480.00

Trailer					
No	Investment	SPECS	Unit	Unit Price (USD)	Total Price (USD)
1	Trailer V1	48.1	0	$ 28,000.00	$ -
2	Trailer V2	61.7	3	$ 31,000.00	$ 93,000.00

OPEX Bintan Island

No	Operational	Unit	Unit Price	Total Price (USD)
1	Crew	12		$ 159,600.00
2	Maintenance of Ship	Year		$ 300,000.00
3	Land Building Tax	Year		$ 19,650.00
4	Driver	3	$720	$ 25,920.00
5	Fuel	165000	$ 0.5	$ 82,500.00

Total

CAPEX	$ 9,472,980.00
OPEX	$ 587,670.00

The table above is a breakdown of the calculation cost of the investment and operating costs on the receiving terminal located on Bintan Island. This receiving terminal serving PLTD Air Raja, PLTMG Tanjung Pinang, PLTD Kota Lama and PLTD Suka Berenang with each power 142.4 MW; 75 MW; 47.8 MW; 84.6 MW. With power explained, LNG consumption each day reaching 3109 m^3. So by using a tank size of 1200 m^3 receiving terminal takes as much as 3 tanks. Referring to the results of the identification of the receiving terminal on the table, estimate the cost of Bintan Island terminal receiving investments are US $9,472,980 and operational costs US $587.670 per year.

4.10.2 Second Route for Karimun Island and Dabo Singkep Island

Table 4. 11 Calculating estimation cost for Karimun Island

CAPEX Karimun

No	Investment	SPECS	Unit	Unit Price (USD)	Total Price (USD)
1	Cyrogenic Pipe	100	per meter	$ 770.00	$ 77,000.00
2	Jetty Facilities	140	per meter	$ 13,300.00	$ 1,862,000.00
3	Land Investment	4000	per m2	$ 143.00	$ 572,000.00
4	LNG Pump	3	up to 2,5 m3/h	$ 13,500.00	$ 40,500.00
5	LNG Pump	3	up to 20 m3/h	$ 24,000.00	$ 72,000.00
6	BOG Compressor	3	per set	$ 93,000.00	$ 279,000.00
7	Vaporizer	2	per set	$ 40,000.00	$ 80,000.00
9	Supporting Building	1	per unit	$ 77,000.00	$ 77,000.00
10	LNG Offloading and Filling station	1	per set	$ 2,600,000.00	$ 2,600,000.00
11	Electric Power Generator	3	per unit	$ 400,000.00	$ 1,200,000.00
12	Trailer V2 LNG	2	per unit	$ 31,000.00	$ 62,000.00
13	LNG Storage Tank 1200	1	per unit	$ 717,160.00	$ 717,160.00

Trailer					
No	Investment	SPECS	Unit	Unit Price (USD)	Total Price (USD)
1	Trailer V1	48.1	0	$ 28,000.00	$ -
2	Trailer V2	61.7	2	$ 31,000.00	$ 62,000.00

OPEX Karimun

No	Operational	Unit	Unit Price	Total Price (USD)
1	Crew	12		$ 159,600.00
2	Maintenance of Ship	Year		$ 300,000.00
3	Land Building Tax	Year		$ 19,650.00
4	Driver	3	$ 720.00	$ 25,920.00
5	Fuel	33000	$ 0.50	$ 16,500.00

Total

CAPEX	$ 7,700,660.00
OPEX	$ 521,670.00

The table above is a breakdown of the calculation of the cost of the investment and operational costs in the receiving terminal located on Karimun Island. It serves to provide receiving terminal PLTU Tanjung Balai Karimun and PLTD Bukit Carok with each 67 MW and 44.4 MW. With power explained, LNG consumption each day reaching 990 m3. So by using a tank size of 1200 m3 receiving terminal takes as much as one tank. Referring to the results of the identification of the receiving terminal on the table, estimate the cost of the investments receiving terminal Karimun Island amounting to the US $7,700,660 and operational costs US $521.670 per year.

Table 4. 12 Calculating estimation cost for Dabo Singkep Island

CAPEX Dabo Singkep

No	Investment	SPECS	Unit	Unit Price (USD)	Total Price (USD)
1	Cyrogenic Pipe	100	per meter	$ 770.00	$ 77,000.00
2	Jetty Facilities	120	per meter	$ 13,300.00	$ 1,596,000.00
3	Land Investment	3000	per m2	$ 143.00	$ 429,000.00
4	LNG Pump	3	up to 2,5 m3/h	$ 13,500.00	$ 40,500.00
5	LNG Pump	3	up to 20 m3/h	$ 24,000.00	$ 72,000.00
6	BOG Compressor	3	per set	$ 93,000.00	$ 279,000.00
7	Vaporizer	2	per set	$ 40,000.00	$ 80,000.00
9	Supporting Building	1	per unit	$ 77,000.00	$ 77,000.00
10	LNG Offloading and Filling station	1	per set	$ 2,600,000.00	$ 2,600,000.00
11	Electric Power Generator	3	per unit	$ 400,000.00	$ 1,200,000.00
12	Trailer V2 LNG	1	per unit	$ 31,000.00	$ 31,000.00
13	LNG Storage Tank 350	1	per unit	$ 405,005.00	$ 405,005.00

Trailer					
No	Investment	SPECS	Unit	Unit Price (USD)	Total Price (USD)
1	Trailer V1	48.1	0	$ 28,000.00	$ -
2	Trailer V2	61.7	1	$ 31,000.00	$ 31,000.00

OPEX Dabo Singkep

No	Operational	Unit	Unit Price	Total Price (USD)
1	Land Building Tax			$ 19,650.00
2	Driver	3	$ 720.00	$ 25,920.00
3	Fuel	26400	$ 0.5	$ 13,200.00

Total

CAPEX	$ 6,917,505.00
OPEX	$ 58,770.00

The table above is a breakdown of the calculation of the cost of the investment and operational costs in receiving terminal located on Dabo Singkep Island. The receiving terminal serves PLTMG Dabo Singkep with a power of 30 MW. With power explained, LNG consumption each day reaching 267 m3. So by using a tank size of 350 m3 LNG terminal on the receiver takes as much as one tank. Referring to the results of the identification of the receiving terminal on the table, estimate the cost of the investments receiving terminal Dabo Singkep Island amounting to the US $6,917,505 and operational costs US $58.770 per year.

4.11 Economical Study

Economic studies conducted in this study covers the cost of investment to distribute the transportation of LNG ships and LNG terminal facilities investment and distribution of LNG on land using trailers heading to power plants. The supplier of LNG bought the LNG from the company that producing LNG and then sell it to a power plant. And then, LNG is converted into gas for use as fuel in power plants. In this economic study, there are two kinds of investment costs such as Capital Expenditure (CAPEX) and Operational Expenditure (OPEX). CAPEX is the costs incurred for the construction of facilities while the OPEX is an operational cost incurred to support the distribution of LNG. In addition, the parameters used in the study of economical is the Internal Rate of Return (IRR), Payback Periods (PP), and Net Present Value (NPV).

4.11.1 Capital Expenditure (CAPEX)

Capital Expenditure or CAPEX is the entire initial investment costs incurred for the construction of facilities that are in the receiving terminal. The investment cost of the receiving terminal facilities consists of the jetty facilities, LNG offloading facilities, land investment, cryogenic pipe, LNG storage tank, pump, vaporizer, LNG BOG compressor, generator, filling station, supporting building and component installation. And some of his supporters in the form of ship transport are Barge Container Skid for distribution at sea and trailers for on land. The investment cost of each receiving terminal has been described before. Based on the results of the selection route optimization with most minimum investment cost estimation obtained a total of the entire receiving terminal of US $24,623,145. Details of the cost of the recipient's terminal investment can be seen in the attachment. Of the total value of the CAPEX required 60% of bank loans and 40% of investors.

Table 4. 13 Details CAPEX receiving terminals

CAPEX		
Receiving Terminal Bintan Island	$	9,472,980.00
Receiving Terminal Karimun Island	$	7,700,660.00
Receiving Terminal Dabo Singkep Island	$	6,917,505.00
Total	$	24,091,145.00

4.11.2 Operational Expenditure (OPEX)

Operational Expenditure (OPEX) is the whole of the costs incurred to support the operations of the LNG distribution including the receiving terminal operating costs and transportation costs for transporting LNG from the source to the receiving terminal. Receiving terminal operating costs divided into maintenance cost, crew, drivers, fuel for trailers and land building tax. Based on the results of the selected route optimization with most investment minimum cost obtained estimated total operating costs or OPEX issued in the first year amounting to the US $1,102.110 and linear for each year.

Table 4. 14 Details OPEX receiving terminals

OPEX	
Receiving Terminal Bintan Island	$ 587,670.00
Receiving Terminal Karimun Island	$ 521,670.00
Receiving Terminal Dabo Singkep Island	$ 58,770.00
Total	$ 1,102,110.00

4.11.3 Revenue

Revenue is the gross income from a business activity already done. On the distribution business of LNG, income derived from profits from the sales of LNG. The profits obtained from the difference between the purchase prices of LNG with the selling price of LNG or can be called a sales margin. To find out if the end of the period the investment already process get the profit and the sale price not too high but the LNG distribution company still makes a profit, revenue calculations need to be done with the varied sales margin. So, obtain the optimum selling price of LNG. In this study, using six variations of margin is the US $1.75 to the US $2 per mmbtu. The next sales margin is multiplied by the number of LNG sold in one year so that brings revenue per sales margin. Revenue gained certainly is different each variation margin sales. This different revenue will affect the payback period. Payback period (PP) is a payback period of investment that has been issued. Calculation of revenue for the US $1.85 sales margins can be seen in the following table.

Table 4. 15 Details revenue for US$ 1.85 margin sale

	Unit	Value
Amount of processed gas	m^3 /year	1.571.840
Amount of processed gas	mmbtu-year	33.323.008
LNG purchase per mmbtu	US$	8.00
Margin per mmbtu	US$	1.85
LNG selling price per mmbtu	US$	9.85
Annual Revenue	US$	$ 61,647,564.80

The table above showed by setting the margin at the US $1.85 per mmbtu and with the amount of gas that is distributed during the one year 33,323,008 mmbtu obtained a revenue per year is the US $61,647, 564.80 because consumers is power plant, then the number of LNG are distributed each year tend to be fixed. Once the revenue is known, then the next step is to calculate payback period, internal rate of return, and net present value. This calculated to ensure the feasibility of the LNG distribution investments to be implemented in economically. In addition, in the calculation need some other data such as interest rates, taxes, and inflation. All the data, in particular, the interest rates are needed because in this study of 60% of the investment cost of bank loans. The number of the interest rates (interest) used is 12%, the value refers to the credit of Bank Mandiri from 31 March 2017. In the table, show the calculation economical study distribution investment on LNG for power plants in Riau Islands with a sales margin of US $1.85 per mmbtu. The investment period is assumed to be for 20 years, with a sales margin of US $1.85 per mmbtu and revenue of US $61,647, 564.80 per year investment will return after 4.8 years since the operation. In addition, the value of other parameters if the sales margin US $1.85 per mmbtu are Internal Rate of Return (IRR) of 22%; Net Present Value (NPV) after 20 years of US $ $33,178, 133.67. The results of calculations for margin sales of US $1.75, US $1.8, US $1.85, US $1.9, US $1.95 and the US $2 per mmbtu can be seen in Table above

Table 4. 16 Details economical study with several margin sale

Margin (USD)	IRR	PP (Year)	NPV
1.75	14%	6.9	$4,679,155.72
1.8	18%	5.5	$14,013,068.08
1.85	22%	4.3	$23,346,980.44
1.9	26%	3.5	$32,680,892.80
1.95	30%	3.1	$42,014,805.17
2	33%	2.4	$51,348,717.53

The table shows that the larger margin, the faster investment return, the greater profit of investment and the greater NPV will be reached.

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CHAPTER V
CONCLUSION AND SUGGESTION

5.1 Conclusion

Based on the data analysis and discussion that has been conducted in the study of the distribution of LNG for the power plant in the Riau Islands, then the conclusion has been obtained as follows:

1. Through the Bin Packing Problem with maximum demand on the capacity of the ships produced two numbers of ship and minimal cost objective functions selected investment due to serve routes throughout the plant in Riau Island. The two routes are Arun – Bintan – Arun and Arun – Karimun – Dabo Singkep – Arun. The cost of investment for each route is US $9,601,050.00 and US $14,739, 005.00.

2. Facilities to be provided for the distribution of LNG for power plants in the Riau Islands are three facilities located in the receiving terminal in Bintan Island, Karimun Island, and Dabo Singkep Island. It also required one ship 5000 m^3 to serve routes Arun – Bintan – Arun, and one ship of 5000 m^3 to serve routes Arun – Karimun – Dabo Singkep – Arun.

3. The on land transportation should be provided for the distribution of LNG in Riau Island is trailer size 61.7 liters with a total as much as 6 trailers. For the first three trailers support in Bintan Island location with the following route T-PLTD Air Raja-T; T-PLTMG Tanjung Pinang-T dan T-PLTD Kota Lama-PLTD Suka Berenang-T. For second are two trailers in Karimun Island the routes are T-PLTU Balai Karimun-T dan T-PLTD Bukit Carok-T. And the last one is one trailer in Dabo Singkep Island the route is T-PLTMG Dabo Singkep-T.

4. For the economic study which has been calculated the most optimal sales margins between the US $1.75 – US $2 with payback period 2.4-6.9 years of operating time for 20 years.

5.2 Suggestion

After performing the optimization distribution of LNG with economic studies, suggest that can be given for the future are as follows:

1. In calculating sailing time of the vessel, it would be better if the speed of the ship is precise between port and voyage. Because, when the ship entered the territory of the port, the ship did not operate at service speed. So time round trip of ship is more accurate.

2. The LNG ship data used refers to the reference based on the types of ships with small size that allows passing through the sea voyage.

3. It would be better if the trestle every receiving terminal should be provide for enough depth to berth every ship.

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ATTACHMENT

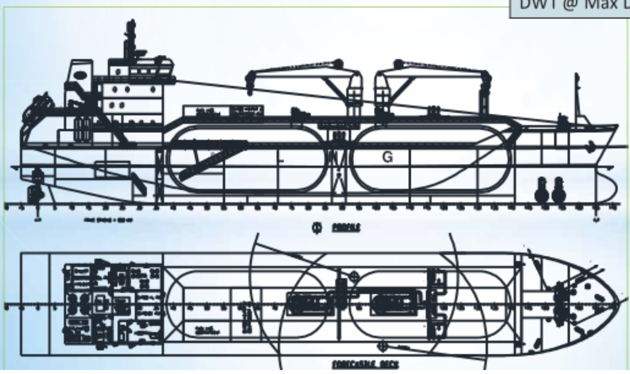
ATTACHMENT A
BCS SHIP DETAIL

Keppel Offshore & Marine Technology Centre

Small-Scale LNG Carriers

5,000 m³ Self Propelled LNG Vessel

Particular	Value	Unit
Length O.A	109.85	m
Breadth Mld	17.90	m
Depth Mld	10.00	m
Max^{m} Draft	4.70	m
DWT @ Max Draft	3,100	tonnes

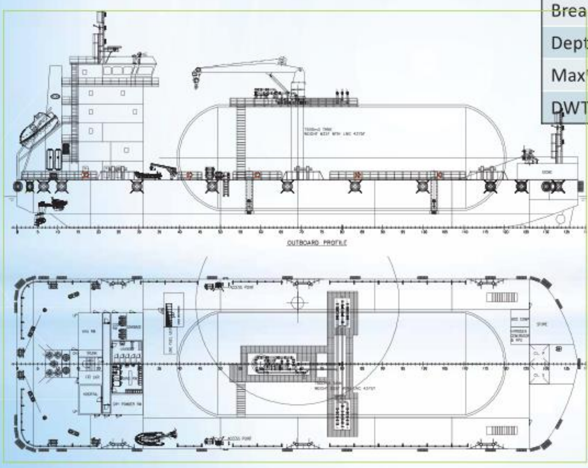


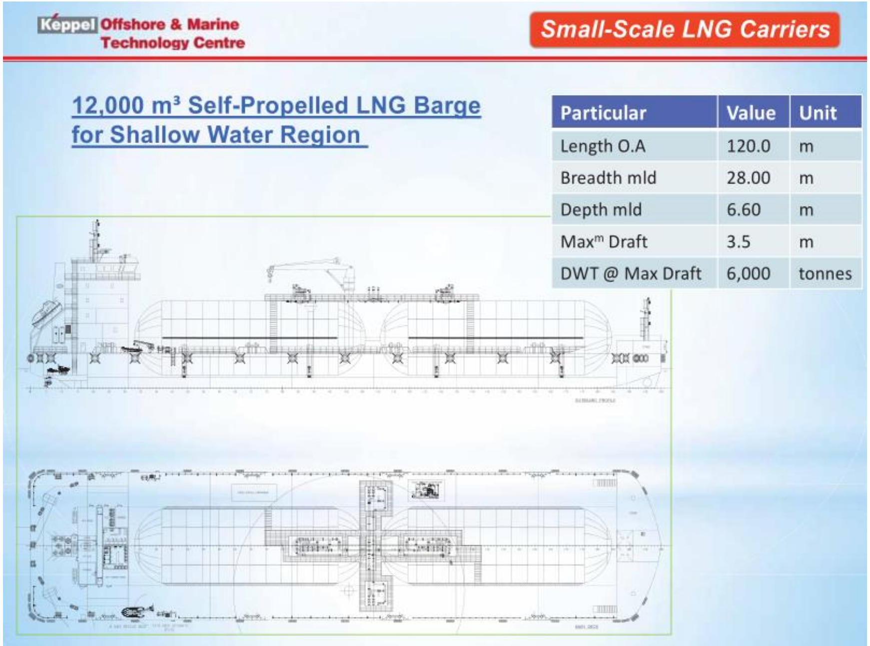
Keppel Offshore & Marine Technology Centre

Small-Scale LNG Carriers

7,500 m³ LNG Shuttle/Bunker Barge (Self-Propelled)

Particular	Value	Unit
Length O.A	82.8	m
Breadth mld	25.00	m
Depth mld	7.00	m
Max^{m} Draft	4.00	m
DWT @ Max Draft	6,000	tonnes




Keppel Offshore & Marine
Technology Centre
Small-Scale LNG Carriers
12,000 m³ Self-Propelled LNG Barge for Shallow Water Region

Particular	Value	Unit
Length O.A	120.0	m
Breadth mld	28.00	m
Depth mld	6.60	m
Max^{m} Draft	3.5	m
DWT @ Max Draft	6,000	tonnes


Keppel Offshore & Marine
Technology Centre
KOMtech Small-Scale LNG Carriers
Small-scale LNG Carriers
Sustainable Marine Transportation Conference 2014
Presented by:
Abul Bashar,
KOMtech

ATTACHMENT B
DATA TRAILERS

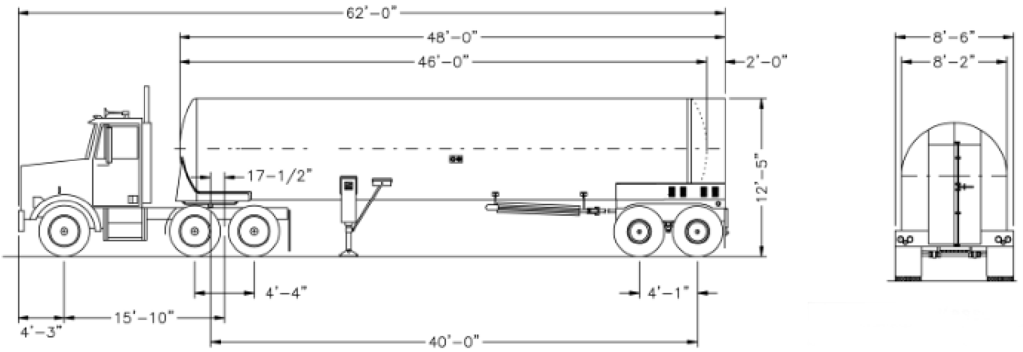
LNG TRANSPORT TRAILERS

PRESSURE TRANSFER UNIT

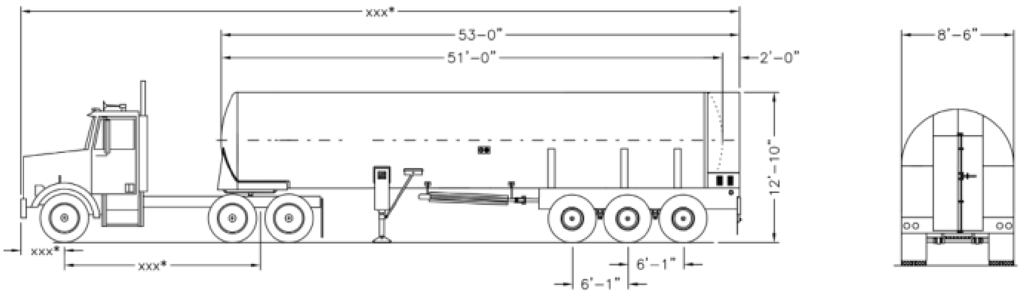
SPECIFICATIONS

Model	ST-12700	ST-16300
Gross Capacity	12,700 gal / 48075 ltrs	16,300 gal / 61,702 ltrs
LNG Capacity (at 70 psig / 4.826 barg)	39,276 lbs / 17,815 kg	50,400 lbs / 22,861 kg
Maximum Allowable Working Pressure	70 psig / 4.83 barg	70 psig / 4.83 barg
Length (overall)	48 ft / 14.6 m	53 ft / 16.2 m
Width (overall)	8 ft 6 in / 2.6 m	8 ft 6 in / 2.6 m
Height	12 ft 5 in / 3.74 m	12 ft 10 in / 3.91 m
Weight	25,200 lbs / 11,431 kg	33,000 lbs / 14,966 kg
Design Codes	ASME Section VIII Division 1	ASME Section VIII Division 1
Axle Configuration	Tandem	Tri

ST-12700



ST-16300



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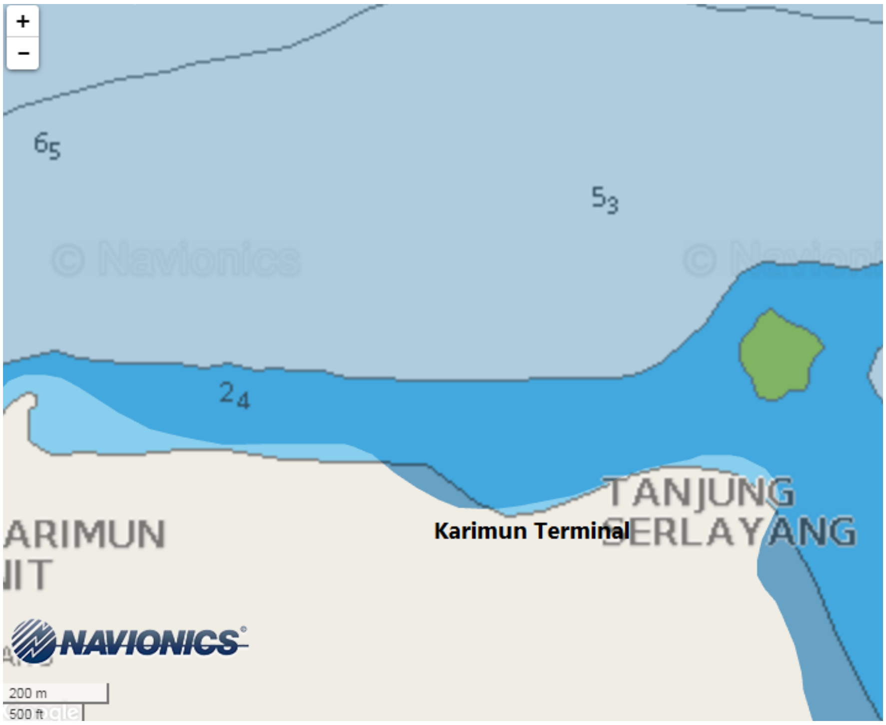
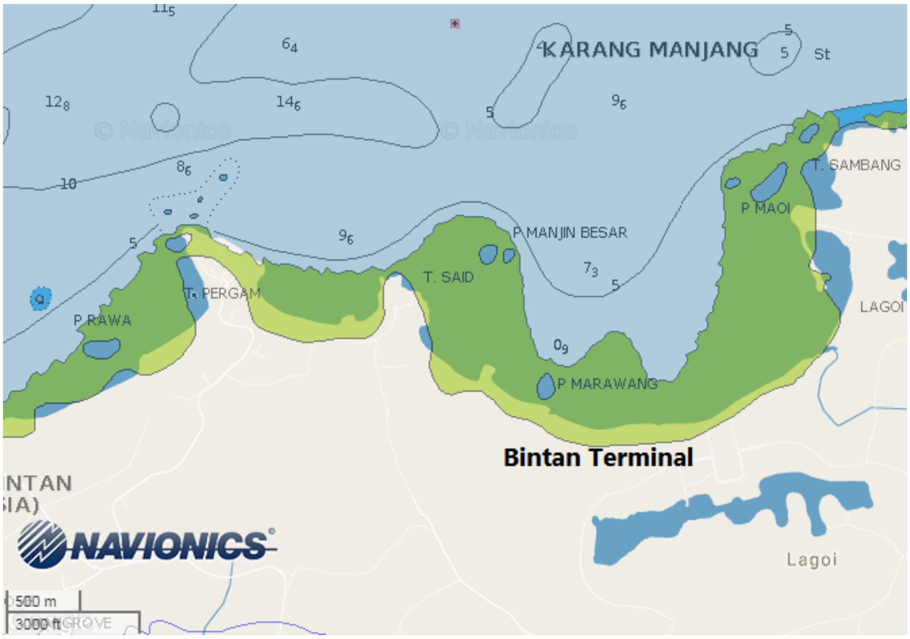
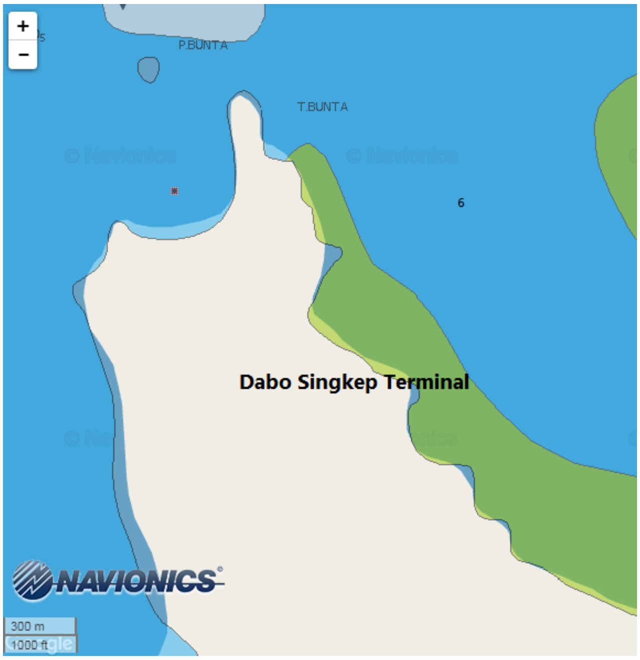
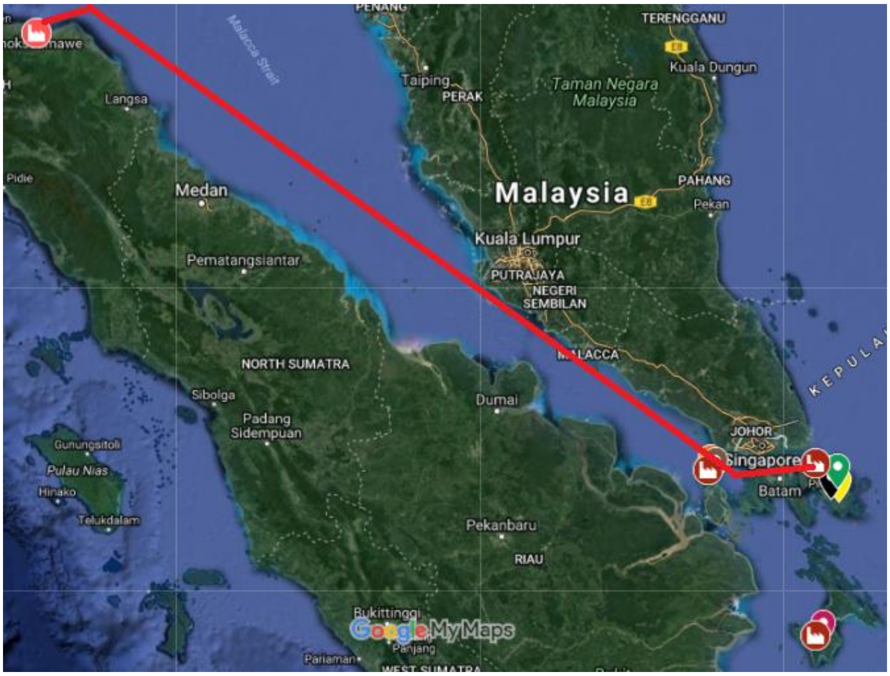
ATTACHMENT C
BATHYMETRY RECEIVING TERMINAL DETAIL

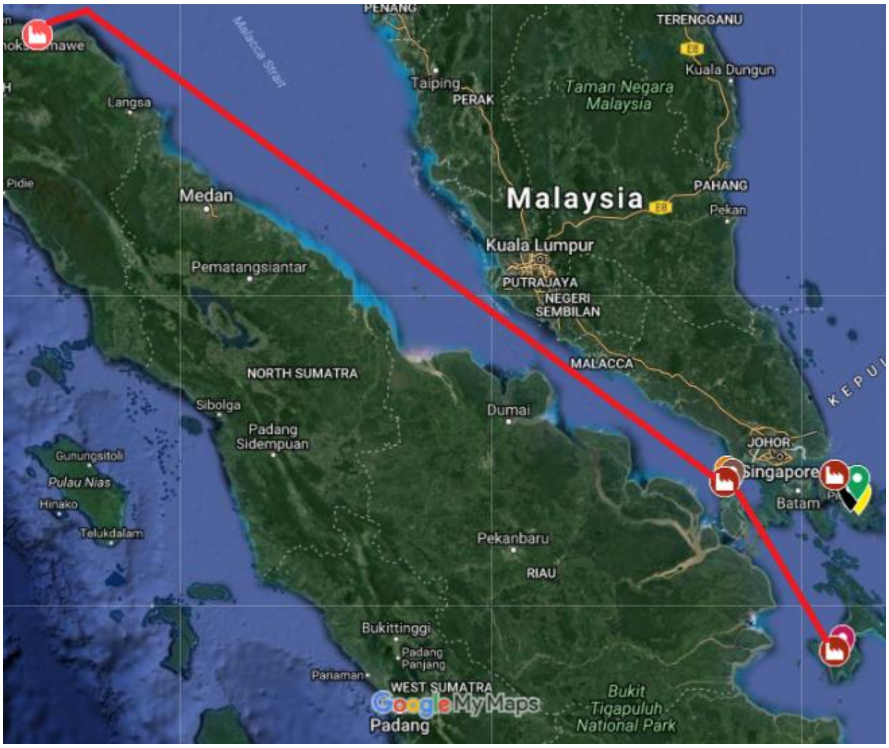





P.BUNTA
T.BUNTA
6
Dabo Singkep Terminal
NAVIONICS
300 m
1000 ft

ATTACHMENT D
NETWORK OF SHIP DETAIL





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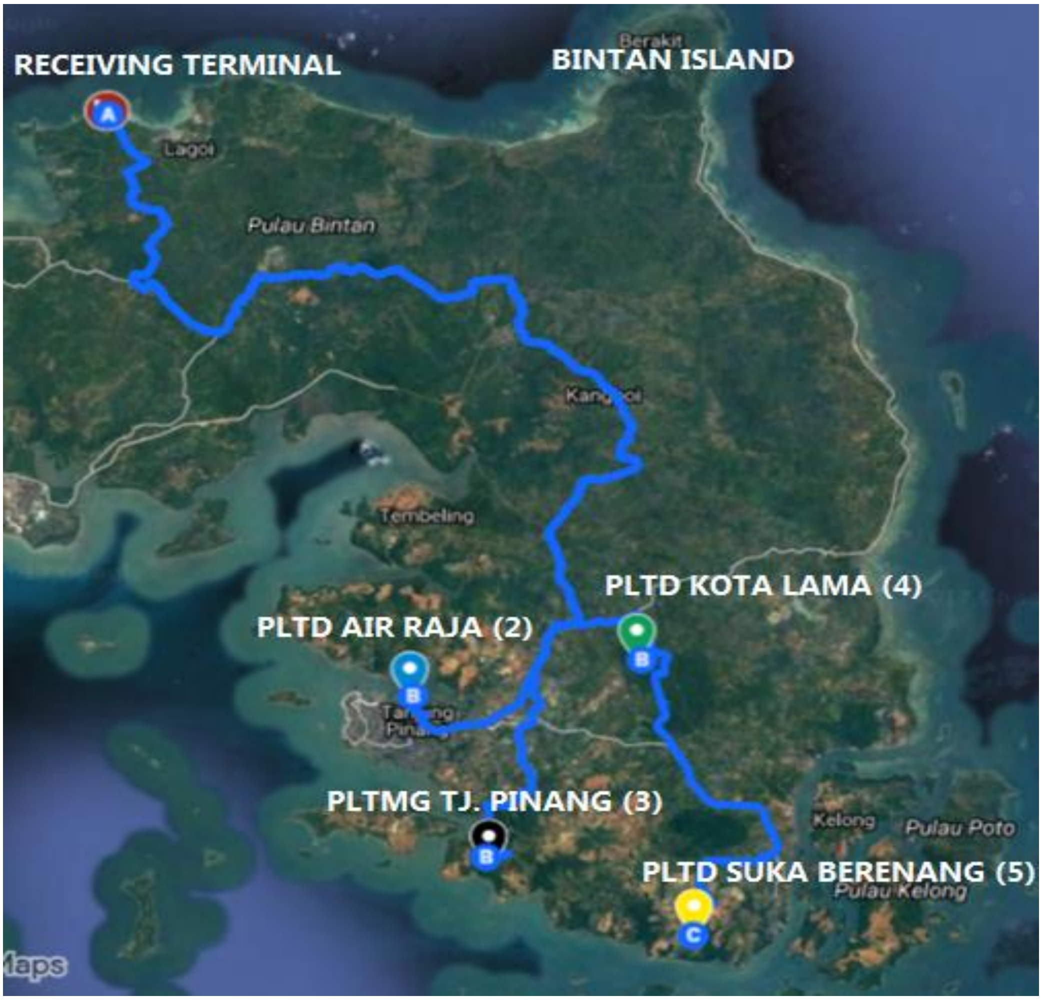
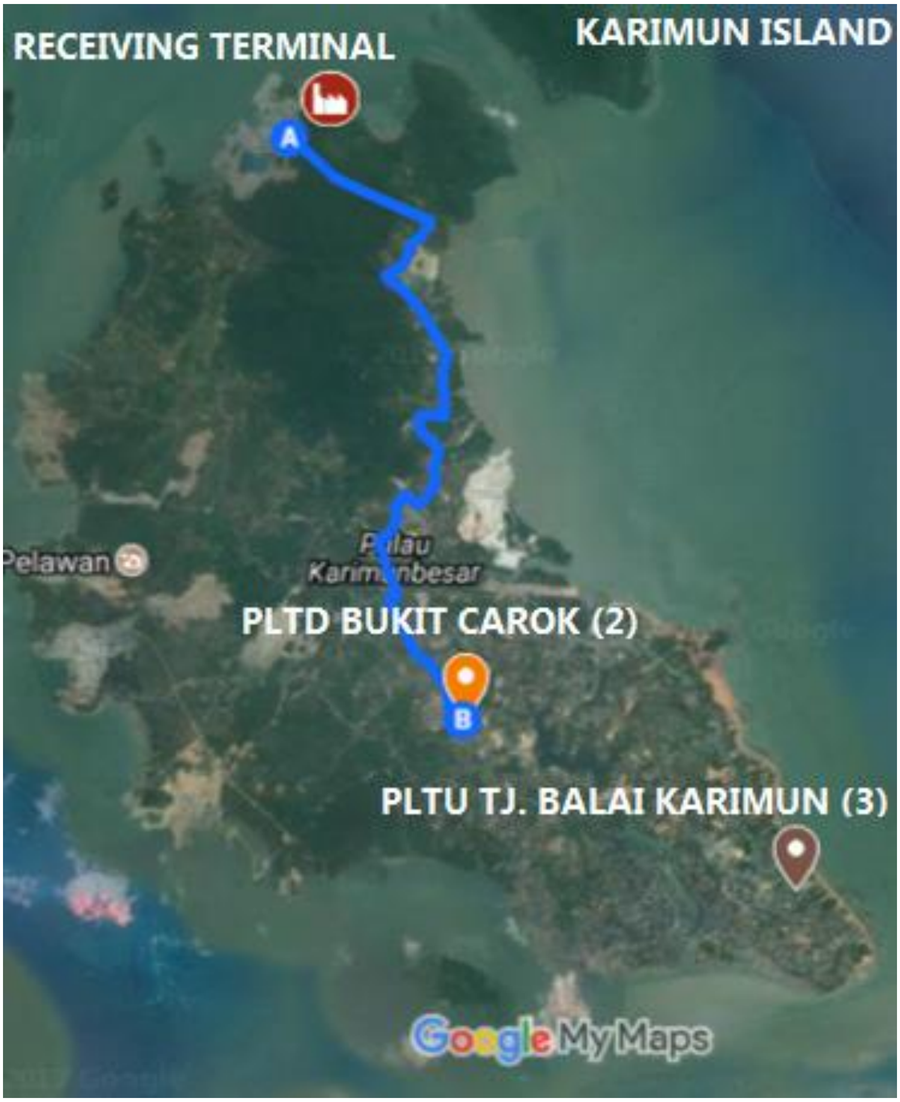
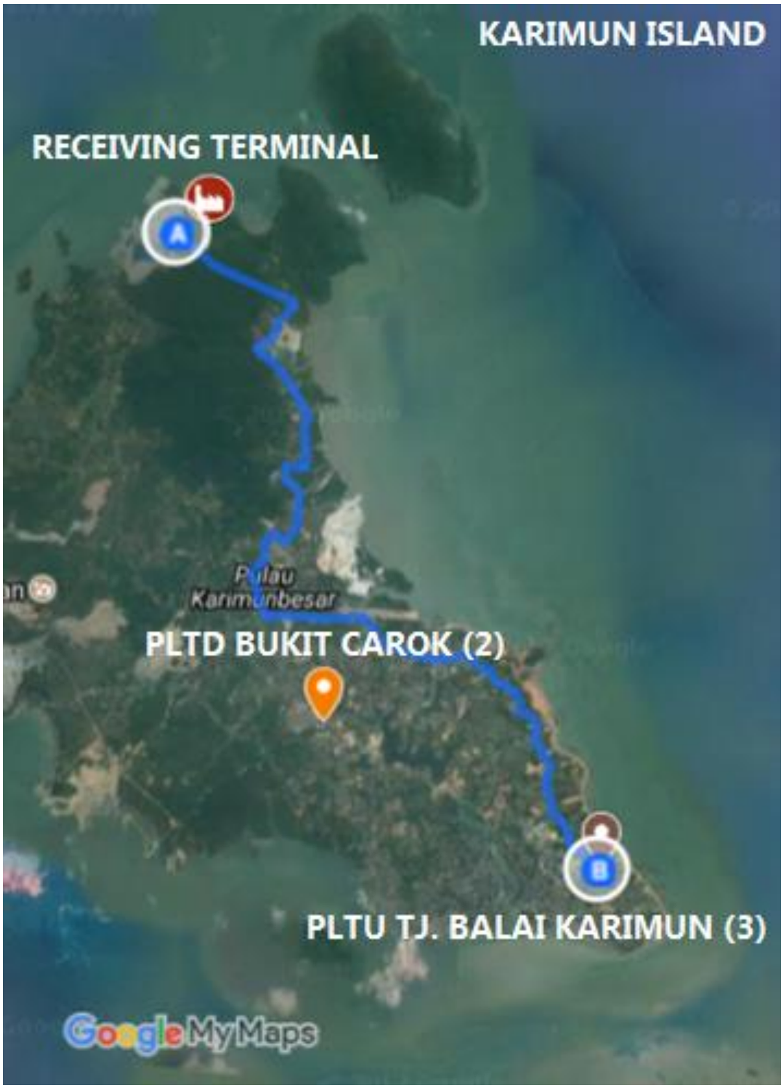
ATTACHMENT E
TRAILER ROUTE DETAIL




RECEIVING TERMINAL
KARIMUN ISLAND
A
Pelawan
PLTD BUKIT CAROK (2)
B
PLTU TJ. BALAI KARIMUN (3)
Google My Maps


KARIMUN ISLAND
RECEIVING TERMINAL
Pulau
Karimunbesar
PLTD BUKIT CAROK (2)
PLTU TJ. BALAI KARIMUN (3)
Google My Maps


DABO SINGKEP ISLAND
RECEIVING TERMINAL
Pulau Singkep
Mosque
Masjid At Taqwa
PLTMG DABO SINGKEP (2)
Google My Maps

ATTACHMENT F
ECONOMY STUDY DETAIL

A. Detail Cost of Office Building (3 unit)

No	Asset	Unit	Cost per Unit		Total Cost	
1	Office Building	3	Rp	3,500,000,000.00	Rp	10,500,000,000.00
		Total			**Rp**	**10,500,000,000.00**

B. Detail Cost of Ship

No	Asset	Unit	Cost per Unit		Total Cost	
1	Barge Container Ship 5000 m3	2	Rp	19,500,000,000.00	Rp	39,000,000,000.00
		Total			**Rp**	**39,000,000,000.00**

C. Detail Cost of Office Inventory

No	Asset	Unit	Cost per Unit		Total Cost		Total Office	Total Price	
1	Computer	12	Rp	8,000,000.00	Rp	96,000,000.00	3	Rp	288,000,000.00
2	Printer	4	Rp	9,200,000.00	Rp	36,800,000.00	3	Rp	110,400,000.00
3	Central Air Conditioner	4	Rp	7,000,000.00	Rp	28,000,000.00	3	Rp	84,000,000.00
4	Office Table	12	Rp	3,000,000.00	Rp	36,000,000.00	3	Rp	108,000,000.00
5	Office Chair	24	Rp	1,000,000.00	Rp	24,000,000.00	3	Rp	72,000,000.00
6	Telephone + Fax	2	Rp	3,000,000.00	Rp	6,000,000.00	3	Rp	18,000,000.00
7	Office Tools	10	Rp	5,000,000.00	Rp	50,000,000.00	3	Rp	150,000,000.00
8	Office Car	2	Rp	200,000,000.00	Rp	400,000,000.00	3	Rp	800,000,000.00
			Total					**Rp**	**1,630,400,000.00**

D. Detail Cost of Power Consumption

No	Power	Unit	Cost per Unit		Total Cost		Total Office	Total Price	
1	Cost of Electricity	12	Rp	3,000,000.00	Rp	36,000,000.00	3	Rp	108,000,000.00
2	Cost of Telephone	12	Rp	3,000,000.00	Rp	36,000,000.00	3	Rp	108,000,000.00
3	Cost of Wifi	12	Rp	900,000.00	Rp	10,800,000.00	3	Rp	32,400,000.00
4	Cost of Fresh Water	12	Rp	1,000,000.00	Rp	12,000,000.00	3	Rp	36,000,000.00
5	Office Logistics	12	Rp	10,000,000.00	Rp	120,000,000.00	3	Rp	360,000,000.00
			Total					**Rp**	**644,400,000.00**

E. Detail Cost of Ship Sailing

Fuel Oil

No	Ship Condition	Numerics		Unit
1	Speed	10.0		knot
2	Distance	3555.22		nm
3	Duration	148.1341667		day
4	Fuel Oil Consumption per Day	5884		litre/day
5	Total Fuel Oil Consmption	11768		litre/trip
6	Ship Operation Time Per Year	330		Day/Year
7	Price of MFO	Rp	6,150.00	Per Litre
8	Total of Trip	660		Trip
9	Total Fuel Oil Consmption per year		7,766,880.00	litre
	Total Cost	**Rp**	**47,766,312,000.00**	Rupiah/Year

Source the price of HFO: PT. Pertamina RU V & MOR VI

Fresh Water

No	Condition	Numerics		Unit
1	Consumption	3000		litre/Trip
2	Total of Trip	660		times
3	Total of Consumption	1980000		litre
4	Price of Fresh Water	Rp	4,500.00	per litre
	Total Cost	**Rp**	**8,910,000,000.00**	per year

MDO			
No	Ship Condition	Numerics	Unit
1	Consumption	1	ton
2	Price	Rp 100,000,000.00	per ton
Total Cost		**Rp 100,000,000.00**	Per Year

Source: http://id.united-oil.com/index.php/product-detail/156-unimar-tbn-60-series
Lube Oil Product is Unimar Tbn 60

Logistic			
No	Ship Condition	Numerics	Unit
1	Cost	Rp 10,000,000.00	per trip
2	Total Trip	660	Times
Total Cost		**Rp 6,600,000,000.00**	Per Year

Logistic is supporting life for the crew ship such as, breakfast, lunch, dinner and coffee break. It is assume so in one trip the value is Rp. 10000000

Berthing			
No	Ship Condition	Numerics	Unit
1	Port Charge Riau Islands	Rp 771,456.00	Per Berthing
	Port Charge Arun	Rp 771,456.00	Per Berthing
Total Port Charge		Rp 1,542,912.00	per total Port in 2 trip
2	Jumlah Trip	660	Times
Total Cost		**Rp 1,018,321,920.00**	Per Year

Port			
No	Ship Condition	Numerics	Unit
1	Port Charge in Riau Island	Rp 715,000.00	per 5 ton
	Port Charge in Arun	Rp 715,000.00	per 5 ton
Total Port Charge		Rp 1,430,000.00	per trip
2	Total of Trip	660	times
Total Cost		**Rp 943,800,000.00**	per year

Total cost of sailing	**Rp**	**65,338,433,920.000**	**Per Year**

F. Detail Cost of Ship Operation

Asurance			
No	Ship Condition	Numerics	Unit
1	Ship Assurance Per Year	5/1000 from price of ship	Rp 195,000,000.000
2	Crew Assurance Per Year	11 Crew + 1 Captain	Rp 2,130,000,000.000
Total Cost			**Rp 2,520,000,000.000**

Maintenance			
No	Ship Condition	Numerics	Unit
1	BCS	2	Rp 1,500,000,000.00
Total Cost			**Rp 3,000,000,000.00**

Classification			
No	Ship Condition	Numerics	Unit
1	BCS	2	Rp 500,000,000.00
Total Cost			**Rp 1,000,000,000.00**

Ship Administration & Document			
No	Ship Condition	Numerics	Unit
1	BCS	2	Rp 500,000,000.00
Total Cost			**Rp 1,000,000,000.00**

Total Cost of Ship Operational	**Rp**	**7,520,000,000.000**	**Per Year**

G. Detail Cost of Employee

Officer Salary								
No	**Position**	**Quantity**	**Salary/Position**		**Salary/Month**		**Salary/Year**	
1	CEO	1	Rp	40,000,000.00	Rp	40,000,000.00	Rp	480,000,000.00
2	Manager	2	Rp	30,000,000.00	Rp	60,000,000.00	Rp	720,000,000.00
3	Head of Technical	2	Rp	25,000,000.00	Rp	50,000,000.00	Rp	600,000,000.00
4	Head of Finance	2	Rp	25,000,000.00	Rp	50,000,000.00	Rp	600,000,000.00
5	Head of Commercial	2	Rp	25,000,000.00	Rp	50,000,000.00	Rp	600,000,000.00
6	Staff of Technical	4	Rp	10,000,000.00	Rp	40,000,000.00	Rp	480,000,000.00
7	Staff of Finance	4	Rp	7,000,000.00	Rp	28,000,000.00	Rp	336,000,000.00
8	Staff of Commercial	4	Rp	6,000,000.00	Rp	24,000,000.00	Rp	288,000,000.00
9	Receptionist	2	Rp	5,000,000.00	Rp	10,000,000.00	Rp	120,000,000.00
10	Security	2	Rp	5,000,000.00	Rp	10,000,000.00	Rp	120,000,000.00
11	Office Boy	4	Rp	4,000,000.00	Rp	16,000,000.00	Rp	192,000,000.00
Total of Salary							**Rp**	**4,536,000,000.00**

Ship Crew Salary								
No	**Position**	**Quantity**	**Salary/Position**		**Salary/Month**		**Salary/Year**	
1	Master (Experience more than 10 years)	1	Rp	25,000,000.00	Rp	25,000,000.00	Rp	300,000,000.00
2	Chief Officer	1	Rp	15,000,000.00	Rp	15,000,000.00	Rp	180,000,000.00
3	Second Officer	1	Rp	10,000,000.00	Rp	10,000,000.00	Rp	120,000,000.00
4	Chief Engineer	1	Rp	15,000,000.00	Rp	15,000,000.00	Rp	180,000,000.00
5	Second Engineer	1	Rp	10,000,000.00	Rp	10,000,000.00	Rp	120,000,000.00
6	Quarter Master	3	Rp	8,000,000.00	Rp	24,000,000.00	Rp	288,000,000.00
7	Foreman	1	Rp	6,000,000.00	Rp	6,000,000.00	Rp	72,000,000.00
8	Oiler	3	Rp	5,000,000.00	Rp	15,000,000.00	Rp	180,000,000.00
9	Chef	1	Rp	6,500,000.00	Rp	6,500,000.00	Rp	78,000,000.00
10	Mess Boy	1	Rp	5,000,000.00	Rp	5,000,000.00	Rp	60,000,000.00
11	Cadet	1	Rp	1,500,000.00	Rp	1,500,000.00	Rp	18,000,000.00
Total of Salary							**Rp**	**1,596,000,000.00**

Total Cost			
No	**Detail**	**Cost**	
1	**Cost of Office Building**	Rp	10,500,000,000.00
2	**Cost of Ship Newbuilding**	Rp	39,000,000,000.00
3	**Cost of Office Inventory**	Rp	1,630,400,000.00
4	**Cost of Power**	Rp	644,400,000.00
5	**Cost of Ship Sailing**	Rp	65,338,433,920.00
6	**Cost of Ship Operational**	Rp	7,520,000,000.00
7	**Cost of Salary (Crew + Officer)**	Rp	6,132,000,000.00
TOTAL COST		**Rp**	**130,765,233,920.00**
		$	**10,058,864.15**

In this case we need to loan to bank because our own finance is only 40% from the total investment

Investment Cost	$	34,398,919.15
Income/Month	$	4,859,605.33
Operation Cost (20 years)	$	1,038,258,920.00
Project Term (years)		20
Tax		25%
Interest		12.00%
Depreciation Method		Linear

Initial Outlay				
Asset dan Installation Buy			$	34,398,919.15
Depreciation Asset			$	34,398,919.15
Net Initial Outlay			$	34,398,919.15

LNG Selling Price per mmbtu 1.75

Annual Cash Flow				
Main Income			$	58,315,264.00
Operation Cost	$	51,912,946.00		
Depreciation Project	$	1,719,945.96		
Income before Tax			$	4,682,372.04
Tax	$	1,170,593.01		
Income after Tax			$	3,511,779.03
Depreciation Revesal			$	1,719,945.96
Annual Cash Flow			$	5,231,724.99

Period (year)	Cash Flow		Payback Periode	
0	$	(34,398,919.15)	$	(34,398,919.15)
1	$	5,231,724.99	$	(29,167,194.16)
2	$	5,231,724.99	$	(23,935,469.17)
3	$	5,231,724.99	$	(18,703,744.18)
4	$	5,231,724.99	$	(13,472,019.19)
5	$	5,231,724.99	$	(8,240,294.20)
6	$	5,231,724.99	$	(3,008,569.21)
7	$	5,231,724.99	$	2,223,155.78
8	$	5,231,724.99	$	7,454,880.77
9	$	5,231,724.99	$	12,686,605.76
10	$	5,231,724.99	$	17,918,330.75
11	$	5,231,724.99	$	23,150,055.74
12	$	5,231,724.99	$	28,381,780.72
13	$	5,231,724.99	$	33,613,505.71
14	$	5,231,724.99	$	38,845,230.70
15	$	5,231,724.99	$	44,076,955.69
16	$	5,231,724.99	$	49,308,680.68
17	$	5,231,724.99	$	54,540,405.67
18	$	5,231,724.99	$	59,772,130.66
19	$	5,231,724.99	$	65,003,855.65
20	$	5,231,724.99	$	70,235,580.64

NPV	$	4,679,155.72
IRR		14%

Investment Cost	$ 34,398,919.15
Income/Month	$ 4,998,451.20
Operation Cost (20 years)	$ 1,038,258,920.00
Project Term (years)	20
Tax	25%
Interest	12.00%
Depreciation Method	Linear

LNG Selling Price per mmbtu 1.8

Initial Outlay		
Asset dan Installation Buy		$ 34,398,919.15
Depreciation Asset		$ 34,398,919.15
Net Initial Outlay		$ 34,398,919.15

Annual Cash Flow		
Main Income		$ 59,981,414.40
Operation Cost	$ 51,912,946.00	
Depreciation Project	$ 1,719,945.96	
Income before Tax		$ 6,348,522.44
Tax	$ 1,587,130.61	
Income after Tax		$ 4,761,391.83
Depreciation Revesal		$ 1,719,945.96
Annual Cash Flow		$ 6,481,337.79

Period (year)	Cash Flow	Payback Periode
0	$ (34,398,919.15)	$ (34,398,919.15)
1	$ 6,481,337.79	$ (27,917,581.36)
2	$ 6,481,337.79	$ (21,436,243.57)
3	$ 6,481,337.79	$ (14,954,905.78)
4	$ 6,481,337.79	$ (8,473,567.99)
5	$ 6,481,337.79	$ (1,992,230.20)
6	$ 6,481,337.79	$ 4,489,107.59
7	$ 6,481,337.79	$ 10,970,445.38
8	$ 6,481,337.79	$ 17,451,783.17
9	$ 6,481,337.79	$ 23,933,120.96
10	$ 6,481,337.79	$ 30,414,458.75
11	$ 6,481,337.79	$ 36,895,796.54
12	$ 6,481,337.79	$ 43,377,134.32
13	$ 6,481,337.79	$ 49,858,472.11
14	$ 6,481,337.79	$ 56,339,809.90
15	$ 6,481,337.79	$ 62,821,147.69
16	$ 6,481,337.79	$ 69,302,485.48
17	$ 6,481,337.79	$ 75,783,823.27
18	$ 6,481,337.79	$ 82,265,161.06
19	$ 6,481,337.79	$ 88,746,498.85
20	$ 6,481,337.79	$ 95,227,836.64

NPV	$ 14,013,068.08
IRR	18%

Investment Cost	$	34,398,919.15
Income/Month	$	5,137,297.07
Operation Cost (20 years)	$	1,038,258,920.00
Project Term (years)		20
Tax		25%
Interest		12.00%
Depreciation Method		Linear

LNG Selling Price per mmbtu 1.85

Initial Outlay				
Asset dan Installation Buy			$	34,398,919.15
Depreciation Asset			$	34,398,919.15
Net Initial Outlay			$	34,398,919.15

Annual Cash Flow				
Main Income			$	61,647,564.80
Operation Cost	$	51,912,946.00		
Depreciation Project	$	1,719,945.96		
Income before Tax			$	8,014,672.84
Tax	$	2,003,668.21		
Income after Tax			$	6,011,004.63
Depreciation Revesal			$	1,719,945.96
Annual Cash Flow			$	7,730,950.59

Period (year)	Cash Flow		Payback Periode	
0	$	(34,398,919.15)	$	(34,398,919.15)
1	$	7,730,950.59	$	(26,667,968.56)
2	$	7,730,950.59	$	(18,937,017.97)
3	$	7,730,950.59	$	(11,206,067.38)
4	$	7,730,950.59	$	(3,475,116.79)
5	$	7,730,950.59	$	4,255,833.80
6	$	7,730,950.59	$	11,986,784.39
7	$	7,730,950.59	$	19,717,734.98
8	$	7,730,950.59	$	27,448,685.57
9	$	7,730,950.59	$	35,179,636.16
10	$	7,730,950.59	$	42,910,586.75
11	$	7,730,950.59	$	50,641,537.34
12	$	7,730,950.59	$	58,372,487.92
13	$	7,730,950.59	$	66,103,438.51
14	$	7,730,950.59	$	73,834,389.10
15	$	7,730,950.59	$	81,565,339.69
16	$	7,730,950.59	$	89,296,290.28
17	$	7,730,950.59	$	97,027,240.87
18	$	7,730,950.59	$	104,758,191.46
19	$	7,730,950.59	$	112,489,142.05
20	$	7,730,950.59	$	120,220,092.64

NPV	$	23,346,980.44
IRR		22%

Investment Cost	$	34,398,919.15
Income/Month	$	5,276,142.93
Operation Cost (20 years)	$	1,038,258,920.00
Project Term (years)	20	
Tax	25%	
Interest	12.00%	
Depreciation Method	Linear	

LNG Selling Price per mmbtu 1.9

Initial Outlay			
Asset dan Installation Buy		$	34,398,919.15
Depreciation Asset		$	34,398,919.15
Net Initial Outlay		$	34,398,919.15

Annual Cash Flow			
Main Income		$	63,313,715.20
Operation Cost	$ 51,912,946.00		
Depreciation Project	$ 1,719,945.96		
Income before Tax		$	9,680,823.24
Tax	$ 2,420,205.81		
Income after Tax		$	7,260,617.43
Depreciation Reveal		$	1,719,945.96
Annual Cash Flow		$	8,980,563.39

Period (year)	Cash Flow	Payback Periode
0	$ (34,398,919.15)	$ (34,398,919.15)
1	$ 8,980,563.39	$ (25,418,355.76)
2	$ 8,980,563.39	$ (16,437,792.37)
3	$ 8,980,563.39	$ (7,457,228.98)
4	$ 8,980,563.39	$ 1,523,334.41
5	$ 8,980,563.39	$ 10,503,897.80
6	$ 8,980,563.39	$ 19,484,461.19
7	$ 8,980,563.39	$ 28,465,024.58
8	$ 8,980,563.39	$ 37,445,587.97
9	$ 8,980,563.39	$ 46,426,151.36
10	$ 8,980,563.39	$ 55,406,714.75
11	$ 8,980,563.39	$ 64,387,278.14
12	$ 8,980,563.39	$ 73,367,841.52
13	$ 8,980,563.39	$ 82,348,404.91
14	$ 8,980,563.39	$ 91,328,968.30
15	$ 8,980,563.39	$ 100,309,531.69
16	$ 8,980,563.39	$ 109,290,095.08
17	$ 8,980,563.39	$ 118,270,658.47
18	$ 8,980,563.39	$ 127,251,221.86
19	$ 8,980,563.39	$ 136,231,785.25
20	$ 8,980,563.39	$ 145,212,348.64

NPV	$ 32,680,892.80
IRR	26%

Investment Cost	$	34,398,919.15
Income/Month	$	5,414,988.80
Operation Cost (20 years)	$	1,038,258,920.00
Project Term (years)		20
Tax		25%
Interest		12.00%
Depreciation Method		Linear

Initial Outlay				
Asset dan Installation Buy			$	34,398,919.15
Depreciation Asset			$	34,398,919.15
Net Initial Outlay			$	34,398,919.15

LNG Selling Price per mmbtu 1.95

Annual Cash Flow				
Main Income			$	64,979,865.60
Operation Cost	$	51,912,946.00		
Depreciation Project	$	1,719,945.96		
Income before Tax			$	11,346,973.64
Tax	$	2,836,743.41		
Income after Tax			$	8,510,230.23
Depreciation Reveal			$	1,719,945.96
Annual Cash Flow			$	10,230,176.19

Period (year)	Cash Flow		Payback Periode	
0	$	(34,398,919.15)	$	(34,398,919.15)
1	$	10,230,176.19	$	(24,168,742.96)
2	$	10,230,176.19	$	(13,938,566.77)
3	$	10,230,176.19	$	(3,708,390.58)
4	$	10,230,176.19	$	6,521,785.61
5	$	10,230,176.19	$	16,751,961.80
6	$	10,230,176.19	$	26,982,137.99
7	$	10,230,176.19	$	37,212,314.18
8	$	10,230,176.19	$	47,442,490.37
9	$	10,230,176.19	$	57,672,666.56
10	$	10,230,176.19	$	67,902,842.75
11	$	10,230,176.19	$	78,133,018.94
12	$	10,230,176.19	$	88,363,195.12
13	$	10,230,176.19	$	98,593,371.31
14	$	10,230,176.19	$	108,823,547.50
15	$	10,230,176.19	$	119,053,723.69
16	$	10,230,176.19	$	129,283,899.88
17	$	10,230,176.19	$	139,514,076.07
18	$	10,230,176.19	$	149,744,252.26
19	$	10,230,176.19	$	159,974,428.45
20	$	10,230,176.19	$	170,204,604.64

NPV	$	42,014,805.17
IRR		30%

Investment Cost	$	34,398,919.15
Income/Month	$	5,553,834.67
Operation Cost (20 years)	$	1,038,258,920.00
Project Term (years)		20
Tax		25%
Interest		12.00%
Depreciation Method		Linear

Initial Outlay				
Asset dan Installation Buy			$	34,398,919.15
Depreciation Asset			$	34,398,919.15
Net Initial Outlay			$	34,398,919.15

LNG Selling Price per mmbtu 2

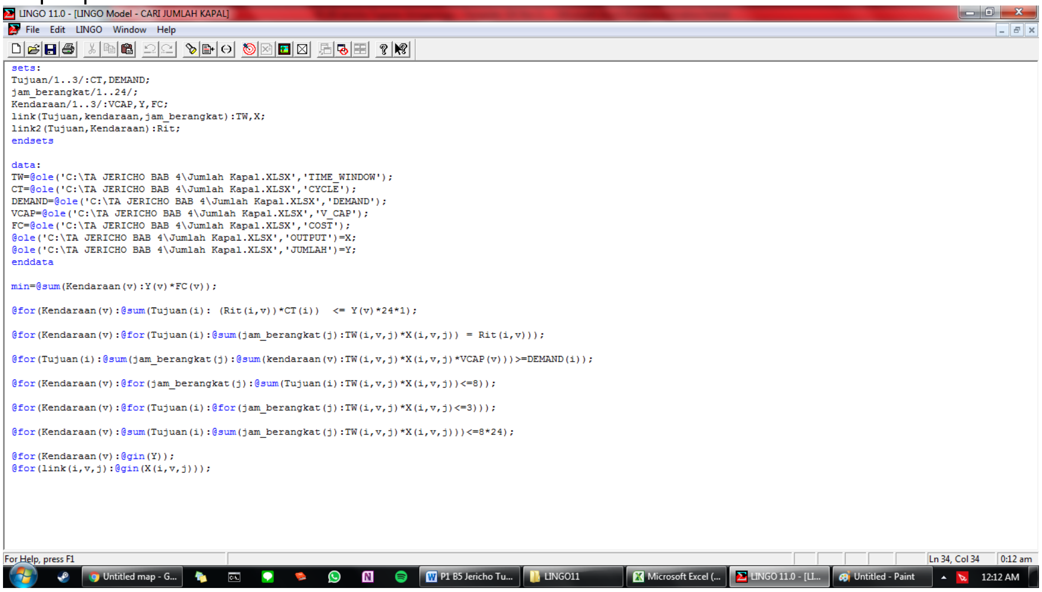
Annual Cash Flow				
Main Income			$	66,646,016.00
Operation Cost	$	51,912,946.00		
Depreciation Project	$	1,719,945.96		
Income before Tax			$	13,013,124.04
Tax	$	3,253,281.01		
Income after Tax			$	9,759,843.03
Depreciation Revesal			$	1,719,945.96
Annual Cash Flow			$	11,479,788.99

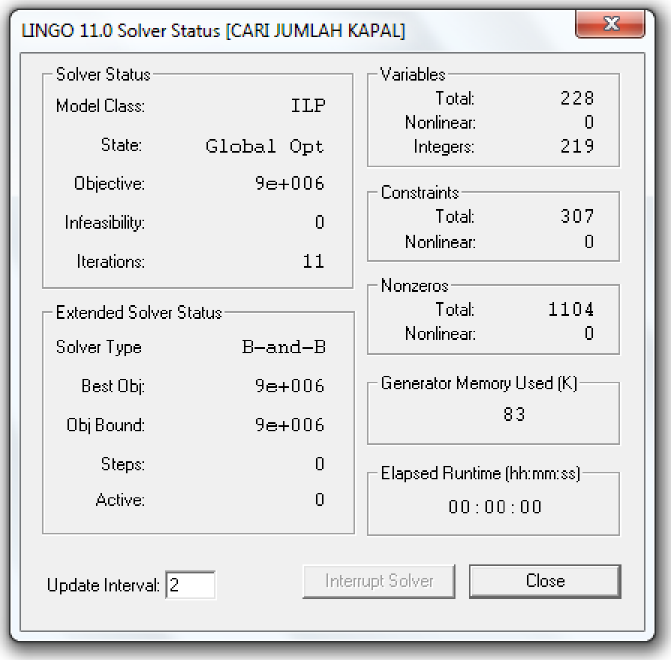
Period (year)	Cash Flow		Payback Periode	
0	$	(34,398,919.15)	$	(34,398,919.15)
1	$	11,479,788.99	$	(22,919,130.16)
2	$	11,479,788.99	$	(11,439,341.17)
3	$	11,479,788.99	$	40,447.82
4	$	11,479,788.99	$	11,520,236.81
5	$	11,479,788.99	$	23,000,025.80
6	$	11,479,788.99	$	34,479,814.79
7	$	11,479,788.99	$	45,959,603.78
8	$	11,479,788.99	$	57,439,392.77
9	$	11,479,788.99	$	68,919,181.76
10	$	11,479,788.99	$	80,398,970.75
11	$	11,479,788.99	$	91,878,759.74
12	$	11,479,788.99	$	103,358,548.72
13	$	11,479,788.99	$	114,838,337.71
14	$	11,479,788.99	$	126,318,126.70
15	$	11,479,788.99	$	137,797,915.69
16	$	11,479,788.99	$	149,277,704.68
17	$	11,479,788.99	$	160,757,493.67
18	$	11,479,788.99	$	172,237,282.66
19	$	11,479,788.99	$	183,717,071.65
20	$	11,479,788.99	$	195,196,860.64

NPV	$	51,348,717.53
IRR		33%

ATTACHMENT G
OPTIMIZATION RESULT DETAIL

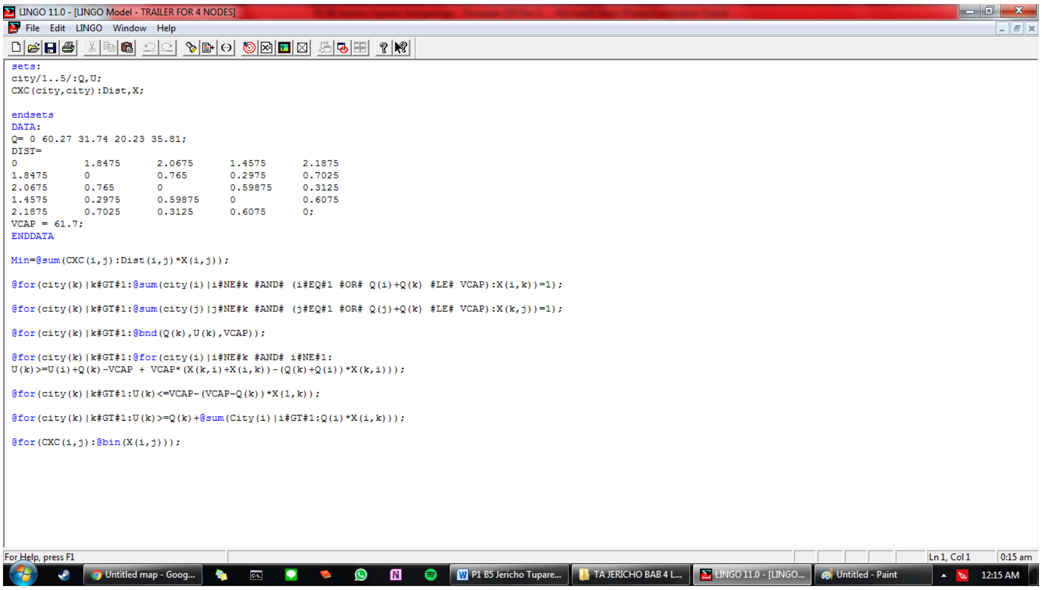
Ship Optimization

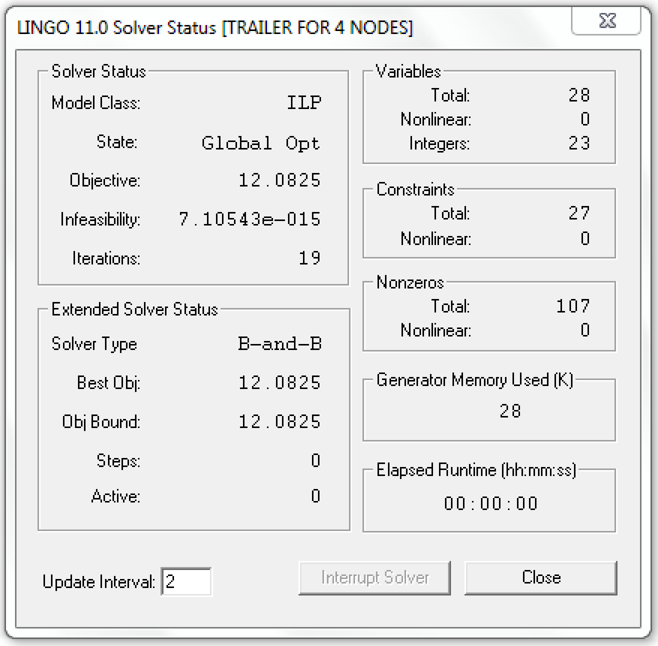




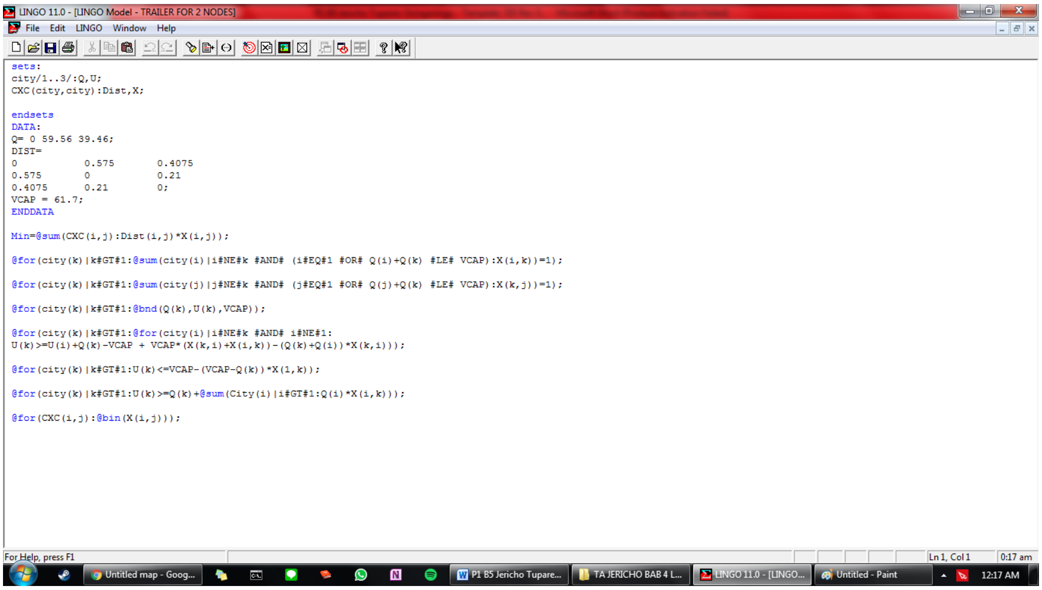
Trailer Optimization

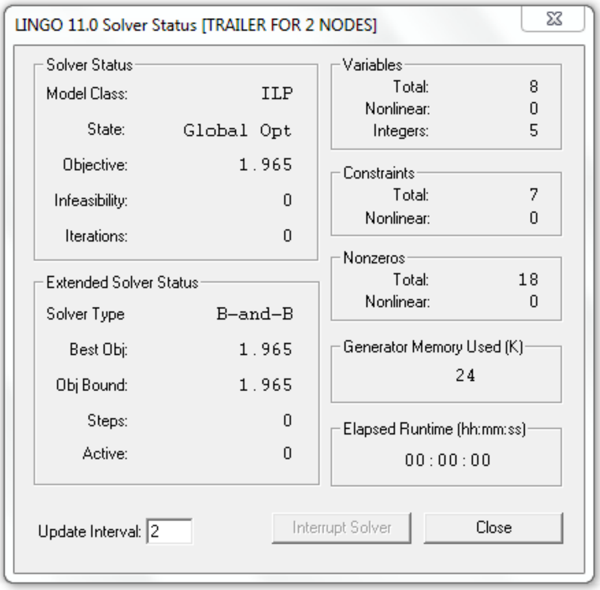
Bintan





Karimun


LINGO 11.0 - [LINGO Model - TRAILER FOR 2 NODES]
File Edit LINGO Window Help
sets:
city/1..3/:Q,U;
CXC(city,city):Dist,X;
endsets
DATA:
Q= 0 59.56 39.46;
DIST=
0 0.575 0.4075
0.575 0 0.21
0.4075 0.21 0;
VCAP = 61.7;
ENDDATA
Min=@sum(CXC(i,j):Dist(i,j)*X(i,j));
@for(city(k)|k#GT#1:@sum(city(i)|i#NE#k #AND# (i#EQ#1 #OR# Q(i)+Q(k) #LE# VCAP):X(i,k))=1);
@for(city(k)|k#GT#1:@sum(city(j)|j#NE#k #AND# (j#EQ#1 #OR# Q(j)+Q(k) #LE# VCAP):X(k,j))=1);
@for(city(k)|k#GT#1:@bnd(Q(k),U(k),VCAP));
@for(city(k)|k#GT#1:@for(city(i)|i#NE#k #AND# i#NE#1:
U(k)>=U(i)+Q(k)-VCAP + VCAP*(X(k,i)+X(i,k))-(Q(k)+Q(i))*X(k,i)));
@for(city(k)|k#GT#1:U(k)<=VCAP-(VCAP-Q(k))*X(1,k));
@for(city(k)|k#GT#1:U(k)>=Q(k)+@sum(City(i)|i#GT#1:Q(i)*X(i,k)));
@for(CXC(i,j):@bin(X(i,j)));
For Help, press F1
Ln 1, Col 1
0:17 am
12:17 AM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Model Class: ILP
State: Global Opt
Objective: 1.965
Infeasibility: 0
Iterations: 0
Extended Solver Status
Solver Type B-and-B
Best Obj: 1.965
Obj Bound: 1.965
Steps: 0
Active: 0
Variables
Total: 8
Nonlinear: 0
Integers: 5
Constraints
Total: 7
Nonlinear: 0
Nonzeros
Total: 18
Nonlinear: 0
Generator Memory Used (K)
24
Elapsed Runtime (hh:mm:ss)
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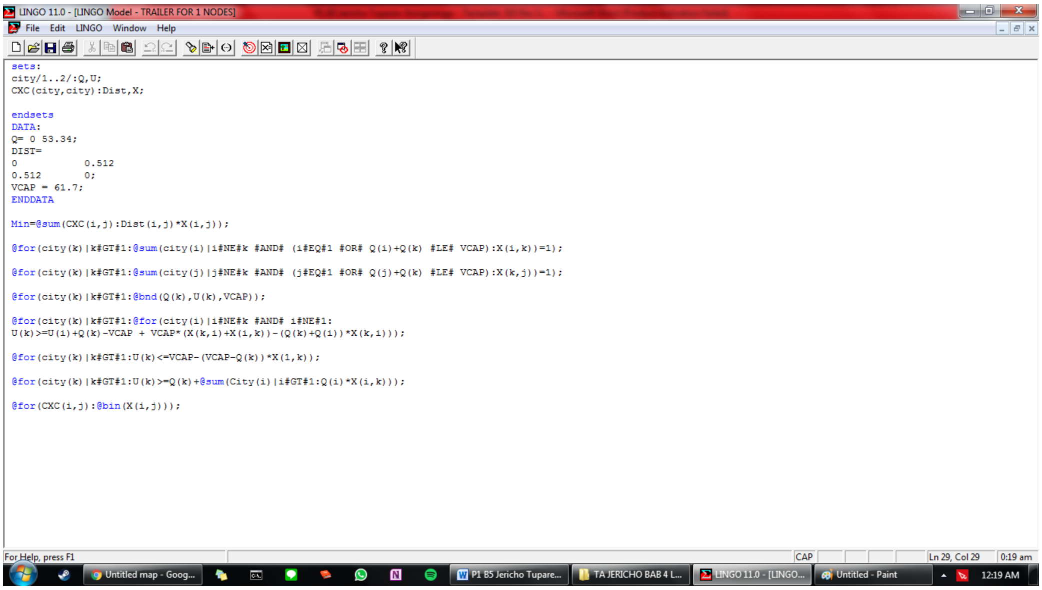
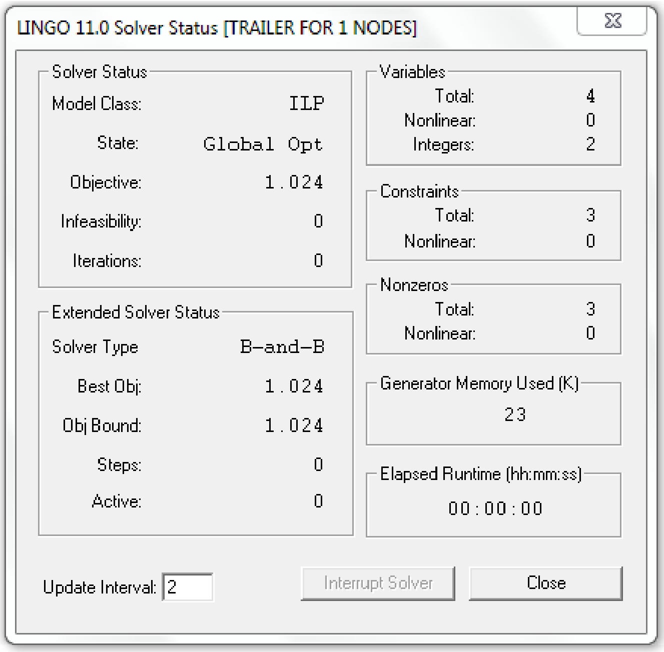
Update Interval: 2
Interrupt Solver
Close

Dabo Singkep





AUTHOR BIOGRAPHY

The writer named Jericho Tuparev Siringoringo was born in Balikpapan, 30th September 1995. During his childhood, the writer lived in South Jakarta until Senior High School. The writer studied elementary school at SD Strada Wiyatasana South Jakarta, junior high school at SMPK Tirta Marta BPK Penabur South Jakarta and senior high school at SMAN 49 South Jakarta. Then the writer continuing education at Department of Marine Engineering Double Degree, Insitut Teknologi Sepuluh Nopember-Hochschule Wismar in 2013. During his college, the writer got part of Christian Student Alliance, Society Petroleum Engineering and ITS Jazz. The writer also part in ITS Jazz event as saxophonist and church activity as saxophonist too. At 3rd year of study, the writer joined Reliability, Availability, and Management (RAMS) Laboratory and finished the study over 8th semester.